ILLINOIS NATURAL HISTORY SURVEY

UNIVERSITY OF ILLINOIS

ANNUAL REPORT

July 1, 2013 through June 30, 2014

Surveys and investigations for sportfish management in lakes and rivers in Illinois

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Submitted to
Division of Fisheries
Illinois Department of Natural Resources
Federal Aid Project F-185

August 2014

INHS Technical Report 2014 (29)

ANNUAL PROGRESS REPORT

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Acknowledgments:

The authors would like to thank the staff at the Kaskaskia, Ridge, and Sam Parr Biological Stations for laboratory and field help. We would also like to thank the regional and district biologists from the Division of Fisheries, Illinois Department of Natural Resources (IDNR) who provided additional lake survey data, especially M. Mounce, M. Hooe, J. Pontnak, and M. Garthaus. S. Pallo, J. Ferencak, J. Mick and D. Bruce helped coordinate activities with the Division of Fisheries, IDNR. Funds for the Lake Paradise vegetation planting were provided by the National Fish and Wildlife Foundation and the City of Mattoon.

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Study 105: Sportfish Sampling Efficiency

EXECUTIVE SUMMARY:

Sportfishing in Illinois is a major recreational activity and source of revenue and proper management of fish populations is paramount to maintaining the quality of the resource. Many different management strategies can be implemented in an attempt to improve the fishery, but are often implemented without adequate evaluation. Management decisions utilize techniques that may improve the fishery in a particular system. Management techniques often are implemented without being evaluated using scientific methods and instead are based on anecdotal evidence. It is important to evaluate management practices in order to understand if they are producing the desired fishery and if the current management action addresses the factors that may be limiting to a fishery. Therefore there is a need for more intensive scientific evaluation of management techniques in order to provide managers with evidence that these techniques can be used to produce the desired benefits.

Stocking is a common tool utilized in Illinois to increase largemouth bass populations. However survival of stocked fish has been documented to be low when stocked on top of natural populations. There are a number of techniques that need to be evaluated to determine if stocking survival can be increased. In Job 101.1, we continued evaluating stocking techniques to improve survival of stocked largemouth bass. Four lakes were stocked with largemouth bass, with half the fish stocked at the boat ramp and half dispersed throughout the lake and into woody or vegetated habitat. Very few stocked fish have been recaptured from any stockings conducted thus far regardless of method and no one stocking method experienced greater growth or survival. The additional handling of netting fish from stocking truck tanks and moving them into release boats, moving them across the lake, and then netting and releasing them, may have resulted in too much additional stress and offset any advantages of the release location. We have provided evidence that distributing fish into habitat will not increase stocking success and recommend other options be pursued to improve survival of stocked fish. We will conduct one additional year of sampling to assess the fish stocked as part of the previous segment.

In addition to largemouth bass, crappie are commonly stocked to enhance populations. Blacknose crappie have recently been used in stocking efforts because of their distinct mark and their ability to survive handling and hatchery truck transport. Blacknose are a type of black crappie that was originally stocked because the distinct mark and the low occurrence in the wild made it easy to identify stocked fish to evaluate stocking success. There has been some suggestion that blacknose crappie have potential growth and fitness advantages over black crappie, but this has been untested in the field. In addition, little is known about the interbreeding of blacknose crappie with native black crappie or the white crappie species.

In Job 101.3, we are evaluating crappie stocking success in Illinois. Although historical stocking of crappie has not been widespread, it has recently gained popularity for managing populations in systems with poor recruitment and/or high angling pressure. In this segment, we completed pond experiments comparing growth and survival of age-0 black, white, and blacknose crappie. There were no differences in survival among the strains, but blacknose crappie grew faster in length and weight than both black and white crappies. Black crappie also grew faster than white crappie in weight but not length. Growth was variable by pond, and environmental variables affected the three strains similarly. Ponds with high zooplankton density, low macroinvertebrate density (mainly dipteran larvae), and low vegetation density had the fastest growth rates. To compare growth and survival among these strains in a larger system, we stocked Ridge Lake with fingerling crappie in the fall of 2013 and have been sampling the lake starting the spring of 2014. We have not detected any juvenile crappie, but this could be due to their invulnerability to standard sampling gears. In the upcoming segment, we will begin sampling the lake with a midwater trawl to try to get estimates of survival and growth for each strain. Blacknose crappie were also stocked in the Marseilles pool of the Illinois River. In this segment, we conducted fall trap and mini fyke netting and electrofishing sampling at the stocking location in order to assess survival and growth. At this time we have not recaptured any of the stocked blacknose crappie. We will conduct modified Missouri trawls this fall in order to attempt to recapture age-1 stocked fish. Further evaluation of the long-term stocking success of black, white, and blacknose crappies is needed to determine the utility of stocking crappie in Illinois.

In Job 101.4, we initiated experiments to evaluate alternative prey acclimation to enhance largemouth bass stocking survival. Data from our previous work suggests that stocked largemouth bass have difficulty switching to fish prey once they are released. We began to evaluate the use of bluegill prey to habituate stocked fish to an elusive prey type common in Illinois lakes. Preliminary tank experiments suggest that there are some differences among fish reared with bluegill compared to minnows or pellets. Minnow reared fish attempt more strikes in order to consume bluegill prey resulting in a lower handling efficiency. Pond experiments were also initiated to test differences in growth and survival of fish reared using bluegill compared to minnows or pellets. Results from pond experiments and additional lab experiments will be presented in reports for future segments.

Harvest regulations are commonly employed by fisheries managers to protect overharvest of fish populations or manage size structure. There are a large variety of regulations used in Illinois with varying management goals. In Job 102.1, we continued to assess largemouth bass populations in lakes with varying harvest regulations. The default largemouth bass regulation in Illinois is no length limit with a 6 fish bag. This was by far the most common regulation, followed by a standard 14 inch 6 fish bag. Slot limits continue to exhibit the most differences from other regulations with greater abundances of young-of-year fish and higher overall catch rates of largemouth bass with good numbers of larger fish. It is unclear if these differences are result of the regulation or an indication of why the regulation was imposed. In addition there is variation associated with slot regulations due to them being less common in Illinois making for weaker comparisons to more common regulations. Lakes with restrictive regulations showed similar largemouth bass size structure and abundance as lakes allowing all harvest. Low harvest rates or poor compliance to regulations may result in lack of differences and will be evaluated in future segments. We attempted to conduct a time series comparison of lakes where regulations changed, but few lakes had FAS data available both before and after a regulation shift.

We also continued to examine crappie regulations in Illinois lakes and how they relate to crappie populations. In Job 102.2, we identified lakes with listed regulations as well as electrofishing data available in the IDNR FAS database from 2007 – 2013. We summarized catch rates of crappie in different size classes and compared them across regulation types. A large majority of lakes in Illinois had unregulated crappie populations. The most common regulation types were bag limits and length/bag limits. Bag limits ranged from 5 -30 fish per day and length limits were either 9 or 10 inches. We found that lakes with length/bag and bag only regulations did not differ from unregulated lakes in size structure and abundance of crappie. Other regulations such as over/under regulations had some evidence of higher numbers of large crappie, but there was limited numbers of lakes where this regulation has been in place long enough to evaluate. We created a time series for 8 lakes where regulations changed to a length and bag limit (n = 4) and an over/under regulation (n = 4). Both types of regulations showed a decline of larger crappie following the implementation of the regulation. Over/Under regulations also showed a decline in abundance of fish just under the size cutoff (6-8”) which may be resulting in the decline of larger fish. We will expand the time series in future segments to increase the sample size of lakes where we can evaluate changing regulations.

Angling tournaments are becoming increasingly popular. Although most tournaments practice live release, there can be high delayed mortality or a variety of sub-lethal impacts of competitive angling tournaments on the individual fish. Previous research has focused on measuring and reducing the stress of individual fish caught in tournaments, but little work has focused on the effect of these practices on the entire fish population. In Jon 102.3, we continued to assess tournament activity and make comparisons with largemouth bass populations in a number of lakes in Illinois. We contacted lake managers and tournament directors to obtain competitive bass fishing tournament results to quantify the level of tournament activity on a lake and relate it to largemouth bass populations. Information from tournaments conducted on 12 lakes from 2002 to the present was used to evaluate varying tournament pressure in addition to 4 lakes with no tournament activity. Tournament pressure (angler hours per acre) varied from 0 to 7.3 hours/acre and the mean number of tournaments a year was 22.1 (range 0 – 58). Larger lakes tended to have larger tournaments with a higher number of participants, but lake size was not related to total tournament pressure. We did not detect any changes in abundance or size structure of largemouth bass vulnerable to tournament angling (> 355 mm) or production of young-of-year fish related to tournament pressure. Non tournament lakes had higher abundances of young-of-year largemouth bass and fewer large fish, but these differences were not significant. We will continue to collect tournament and largemouth bass population data on these lakes and add additional lakes to this analysis as part of future segments to further understand the influence of tournaments on largemouth bass populations.

In addition, we have conducted experimental tournament angling on Ridge Lake in order to determine how tournaments can effect reproduction, abundance, and growth of largemouth bass. In this segment, we did not conduct spring largemouth bass tournaments in order to compare this year to years with tournaments as a control. We have conducted 3 years of spring tournaments while fish were on the nest and compared the changes in the fish population to 6 control years with no tournaments. We observed no consistent changes in young-of-year production or adult abundance for largemouth bass that was related to tournament activity in the spring. We will continue to alternate tournament and no tournament years to further evaluate the potential effects of tournaments on lake wide recruitment.

In addition to stocking and regulations, habitat restoration is critical to managing sportfish populations. The lack of suitable habitat for sportfish spawning, feeding and cover from predators can greatly limit a population. Understanding the importance of habitat and how to manage habitat conditions is important to managers. In Job 103.1, we have continued to conduct habitat manipulations in a number of lakes in an attempt to enhance largemouth bass populations. We continue to evaluate vegetation plantings at Lake Paradise, drawdown and rotenone efforts at Dolan and Woods Lakes, and vegetation removal through chemical treatments at Airport and Stillwater Lakes. We have observed little change in largemouth bass populations at Lake Paradise due to difficulties in establishing vegetation. Woods Lake is currently drawn down and will be rotenone treated to remove gizzard shad and carp this winter. We will begin evaluating fish populations when it is allowed to refill. Dolan Lake was drawn down to encourage vegetation establishment and rotenone treated to remove gizzard shad and carp.

Despite a rebound in the gizzard shad densities, carp have not reestablished in the lake and the vegetation cover has significantly increased coinciding with an increase in largemouth bass densities in this lake. Vegetation removal treatments at Airport Lake have been successful at reducing vegetation densities in the spring and summer, but vegetation reestablishes in the lake by fall requiring annual treatment to retain open water in the shallow lake. Stillwater Lake was successfully treated for vegetation in 2010 and 2012 and the lake initially had a significant decrease in vegetation density following treatment, but vegetation did begin to reestablish after the second year. We have observed no changes in adult largemouth bass density in vegetation treated lakes, but have also found a decline in young-of-year largemouth bass. Decreased survival of young-of-year may lead to declines in adult populations. We will continue to follow vegetation treatment lakes and assess changes in largemouth bass populations.

We have also been measuring vegetation density and cover in 11 lakes and evaluate how largemouth bass populations vary among different vegetation types, cover, and fluctuations in vegetation. The perimeter of the shoreline that is vegetated did not change seasonally, but the total vegetated area did suggesting that the amount of vegetation growth in a lake varied across seasons. We provide evidence that adult largemouth bass populations were positively related to vegetated area of lakes in the fall of 2013. High abundances of adult largemouth bass in the spring of 2014 resulting in a strong year class of young-of-year fish. Although this trend was observed in 2013-2014, it has not been consistent in previous years. We separated lakes into categories of high, medium, and low vegetation and found no significant differences in adult or young-of-year largemouth bass CPUE in electrofishing samples among groups. We will continue to evaluate these relationships to determine the importance of vegetative habitat to largemouth bass recruitment. Vegetation has traditionally been related to prey resources (benthic invertebrates, zooplankton, prey fish) however it was not significantly related in 2013. In this segment we began to develop and implement side scan sonar mapping techniques to quantify vegetation and woody habitat in lakes. We conducted shoreline transects on all lakes and imported images into GIS. We will develop quantification techniques and report finding in future segments. We will develop protocols for use by other biologists in Illinois. We will also continue to evaluate trends in fish populations related to vegetation density in future segments.

It is important to quantify habitat in a system in order to fully understand factors that may be limiting a fishery. In mid-sized rivers there is not a standardized method for evaluating habitat in Illinois. Research is needed to create a habitat evaluation method for mid-sized rivers and relate these habitat measures to fish populations. In Job 103.2, we conducted habitat mapping using side scan sonar and transect methods to quantify substrate, woody structure, depth, and flow characteristics in the Kaskaskia River. We conducted habitat targeted electrofishing samples to evaluate fish assemblages and abundance associated with different habitat types. We observed the highest catch rates over gravel substrate, in wooded habitat, shallower sites, and on the inside bends of the channel. In particular, crappie were significantly more abundant in wooded sites. We will report on habitat and fish assemblage differences between different segments of the Kaskaskia River and expand to other river systems in future segments.

Reproduction and the survival of fish to adulthood can be influenced by a multitude of factors. Understanding variables related to recruitment of fish populations can aid in developing management strategies or identifying limiting factors in a system. Many management practices are focused on enhancing natural recruitment by reducing mortality through practices such as fishing refuges or escapement barriers. Fishing refuges can limit disturbance of fish populations during spawning and protect juvenile and adult fish from fishing mortality and may increase natural recruitment, but have not been well evaluated. In Job 104.1, we continued to assess two fishing refuges in Otter Lake to determine the potential benefits to spawning and survival of largemouth bass. There is little evidence that closing these areas to angling has led to increased reproduction or enhanced largemouth bass populations in the first 4 years following implementation of the refuge. These results contradict what was observed at Clinton Lake where both young-of-year and adult largemouth bass were observed in greater numbers inside the closed refuge. Otter Lake refuges were removed in the spring of 2014. We will continue to follow changes in the largemouth bass population in Otter Lake to determine how they are influenced by closing and reopening of fishing refuges.

Emigration or “escapement” of sportfish from reservoirs over the impounding barrier is commonly viewed as a major limitation in the successful development of high density populations. Reports and anecdotal evidence suggest that this problem is particularly ubiquitous for muskellunge in the Midwest. However, little documented information exists on the patterns and magnitude of escapement, particularly for fish that occur in low densities such as muskellunge. In Job 104.2, we continued to monitor muskellunge escapement in Lakes Mingo and Sam Dale. Both lakes have a PIT tag array installed on the spillway that will monitor the passage of any tagged fish. Muskellunge were captured in the spring during four weeks of fyke netting. We determined population estimates using mark recapture techniques and PIT tagged all muskellunge upon release. Despite observing high levels of spillway escapement in 2011 at Sam Dale, escapement was not observed in either lake in 2012 or 2013. In both years there was little flow over the dams due to dry summer seasons and we did not observe any escapement of muskellunge. Spring rain in 2013 has provided the potential of spillway escapement, but none was observed. In years with high flood occurrence, our results indicate that up to 25% of the muskellunge population in these two reservoirs can escape in a single year. However, in a dry year with some spring flooding, we detected no escapement in these same reservoirs. Therefore, it appears escapement is linked to precipitation events and daily movement behaviors of the fish. Fish were more likely to escape in the spring when large pulses in precipitation occur and most escapes occurred during the daylight hours. This segment concludes this job and all objectives were met. Further research is needed to determine the magnitude of muskellunge and other species escapement in lakes with varying spillways and across years with varying weather.

In Job 104.3, we continued to evaluate crappie recruitment in a number of lakes. We conducted spring and fall electrofishing and fyke netting to assess white, black, and blacknose crappie populations. We collected fish for dissection and otolith reading to determine age, growth, and maturity status. We also collected samples to assess prey resources and predator abundance in each study lake. We collected monthly water quality, zooplankton, larval fish and seasonal benthic invertebrate samples. Vegetation was surveyed in June and August and water level was recorded. Otoliths and scales were aged and it was concluded that otoliths age the preferred method for aging as scale estimates were variable. Fyke netting caught more crappie than electrofishing, but catch rates were variable in the spring due to spawning activity. Age-2 and smaller crappie were not well represented in fyke nets. We will determine if this is due to poor year classes or gear efficiency as we collect future data. White crappie were found in higher abundances and had higher growth rates than black crappie in sympatric systems. We will continue to evaluate factors driving recruitment with additional years of data collection. In future segments we will use these data to determine what factors are related to crappie recruitment and make recommendations for managing crappie populations.

In order to assess sportfish populations and compare populations across Illinois, it is critical to use standardized gears that are efficient in collecting the targeted fish species. Standardized practices for population assessments in Illinois have traditionally been AC shoreline electrofishing. Alternative electrofishing gears using direct current have become more popular recently due to perceived greater efficiency for certain species of fish. There is a need to evaluate how catch rates vary between the AC and DC electrofishing in order to compare historic data if gear changes are made. In Job 105.1, we expanded our comparative AC and DC electrofishing runs to 15 lakes in spring of 2014 and will conduct spring and fall sampling in future segments. Largemouth bass catch rates were very similar between gear types for young-of-year fish, but this was not the case for larger largemouth bass which had greater CPUE in DC electrofishing runs. We also observed increased catch rates for common carp using DC gear. These data suggest that DC gear may work better with larger fish that can generally escape the AC electric field prior to being netted. We will examine size biases of the gears in more detail in future segments. Crappie catch rates were low using both gears and electrofishing may not be a good method for evaluating their abundance. We will continue to conduct AC and DC sampling on the expanded number of lakes and future analyses will focus on more species and the size of fish that is captured.

Study 101: Sportfish Enhancement

Job 101.1: The effects of dispersed versus point stocking on largemouth bass survival and growth.

Objectives: To compare various stocking strategies for largemouth bass.

Introduction:

Fish stocking is common throughout North America for a number of species. Fish may be stocked to introduce a species to a new system (Dauwalter and Jackson 2005), sustain a population in areas where the fish do not reproduce naturally (Santucci et al. 1994), supplement wild populations that have been reduced due to anthropogenic influences (i.e. fishing, habitat degradation; Wingate 1986) or to alter the genetics of a population (Maceina et al. 1988; Buckmeier et al. 2003). The initial success of a stocking program depends on the survival of introduced fish. Much research examining the success of stocking programs has focused on initial survival (Boxrucker 1986; Buckmeier and Betsill 2002; Hoffman and Bettoli 2005), though more recent work has focused on survival to adulthood (Diana and Wahl 2008; Buynak and Mitchell 1999; Wahl and Stein 1993).

Supplemental stocking of largemouth bass *Micropterus salmoides* is a commonly used management tool to enhance populations. Supplemental stocking efforts are directed at either increasing harvest rates and reproductive potential, or restoring predator/prey balance in a fish community. However, for these positive benefits to occur, stocked fish must contribute to the natural population. Numerous studies have examined either the introductions of different genetic stocks of largemouth bass (Rieger and Summerfelt 1978; Maceina et al. 1988; Mitchell et al. 1991; Gilliland 1992; Terre et al. 1993) or the introductions of largemouth bass into ponds (Dillard and Novinger 1975; Modde 1980; Stone and Modde 1982). Surprisingly, few studies have examined the factors thought to influence supplemental stocking of largemouth bass. The few studies that have examined the contribution of stocked largemouth bass to a natural population, examined only one (Lawson and Davies 1979; Buynak and Mitchell 1999) or two lakes (Boxrucker 1986; Ryan et al. 1996). Given that lakes are highly variable, examining stocking evaluations from only one or two lakes limits our ability to make generalizations.

In previous studies, we have evaluated various aspects of largemouth bass stocking success with the goal of increasing survival and growth. We examined the potential benefits of stocking larger fish by comparing the stocking success of four sizes of largemouth bass (Diana et al. 2009), but found no differences in survival and growth of 4, 6, and 8 inch fish. We recommended stocking four inch fish based on cost benefit analyses and the lack of survival of larger fish. We also evaluated different rearing techniques by comparing growth and survival of largemouth bass produced in raceways to those produced in rearing ponds (Diana et al. 2011). Although initial survival and growth of extensively reared fish was significantly higher, long-term survival was low and no differences in rearing technique were observed. Despite low long-term survival of stocked fish, using genetically marked fish we were able to verify that stocked fish are successfully spawning and contributing to young-of-year production (Diana et al. 2011). There is a continued need to attempt to increase survival of stocked largemouth bass by identifying the factors limiting their long-term survival. Largemouth bass are typically stocked at the boat ramp in a point stocking style. We hypothesize that by distributing fish throughout the lake, there is potential for increased dispersion of fish and better survival when stocked into cover such as vegetation or wood. In previous studies, we began comparing point versus dispersed stocking of largemouth bass but low initial survival of stocked fish has limited our ability to draw strong conclusions. In this project, we are conducting additional years of stockings to evaluate their success.

<u>Procedures</u>:

This job continues research initiated as part of previous studies F-135-R evaluating the influence of stocking location on survival of stocked largemouth bass. Otter Lake, Homer Lake, Lake Mingo, and Lake Charleston (n=4) were stocked with 100mm largemouth bass fingerlings using two stocking techniques. In this segment, half of the fish at each lake were stocked at the boat ramp, directly from the hatchery truck, while the other half will be loaded into aerated hauling tanks in boats and distributed throughout the lake. Distributed stockings targeted placing fingerlings into wood and vegetated habitat dispersed throughout the lake. Fish were marked with a pelvic fin clip two weeks prior to stocking at the Jake Wolf Memorial Fish Hatchery. Fish stocked at the boat ramp were given a left pelvic fin clip and fish to be dispersed were given a right pelvic fin clip. Lakes were sampled two times in the fall and two times in the spring using DC or AC 3-phase electrofishing. Three 30 minute electrofishing transects were performed on each sampling date and all largemouth bass were collected, measured for total length, examined for clips, and scales were collected from all clipped fish for age determination. CPUE was calculated for stocked and wild fish and contribution of stocked fish to the total bass population was calculated. The CPUE from this segment was combined with the data from previous stockings in the same lakes. Catch rates and mean size were calculated for each year class and compared between the two rearing techniques. CPUE from electrofishing was calculated and differences between stockings were examined using repeated measures ANOVA and Tukey-Kramer (T-K) adjusted P value were used to determine significance in post hoc tests.

<u>Findings</u>:

Four lakes were stocked with four inch largemouth bass in 2013 for comparison of boat ramp and dispersed stocking. All lakes continued to have very low survival of both boat ramp and dispersed stocked fish to the first fall following stocking (Table 101.1). Continued low survival of the stocked fish from both stocking methods has demonstrated no increase in survival of stocked largemouth bass by initiating this alternative stocking method. There were no significant differences in mean CPUE of boat ramp or dispersed stocked fish in the first fall following stocking and catch rates the following spring are very low. We have continued to recapture some fish from previous stockings in our electrofishing samples, but the CPUE is very low and there is no consistent difference between stocking method (Figure 101.1). The poor survival of all stocked fish may be caused by the warm water temperatures on the date of stocking which occurs in early August. High mortality of dispersed fish could be affected by the increased handling time associated with loading the fish onto a boat and dispersing them throughout the lake. We did not however observe good survival of fish stocked at the boat ramp where this handling did not occur. Evaluation of dispersed stocking of largemouth bass has resulted in no increased survival. We therefore conclude that distributing fish around a lake into different habitats will not enhance stocking success over traditional boat ramp release of largemouth bass. Survival for both stocking methods is low and we suggest identifying other restoration efforts such as habitat or predator management as an alternative to supplemental stocking when attempting to enhance largemouth bass populations.

Recommendations:

We have observed very low survival of largemouth bass stocked both at the boat ramp and dispersed throughout the lake. We anticipated that fish distributed throughout the lake and stocked into habitat may have a survival advantage over boat ramp stocked fish because they were not concentrated and may be less vulnerable to predation. In addition prey resources should be more available to distributed fish. These conditions however did not result in increased growth or survival of largemouth bass. The additional handling of netting fish from stocking truck tanks and moving them into release boats, moving them across the lake, and then netting and releasing them, may have resulted in too much additional stress and offset any advantages of the release location. Every attempt was made to reduce stress throughout the process. Aerated tanks were used on release boats and fish were tempered to lake temperatures prior to being removed from the hatchery truck. Lake water was used in the release boat tanks and fish were not placed into the tanks in densities higher than in the hatchery truck. Netting was done as quickly and carefully as possible. Very low mortality was observed in the release boat tanks or at the time of stocking. Despite these efforts, survival of these fish to the fall was low and long term survival was almost zero. Survival may have been limited due to the high temperatures on the dates of stocking or the increased handling time due to the stocking techniques. We suggest attempting to stock the fish during the lowest possible temperatures to facilitate survival. After seven years of evaluating these stocking strategies in 4 lakes, we observed no evidence that distributed stocking of largemouth bass has any advantage over boat ramp stocking to enhance stocking success. Additional research should focus on alternative stocking techniques such as acclimating stocked fish to natural prey and predators prior to stocking to evaluate if stocking success can be enhanced for largemouth bass. We recommend that managers attempting to enhance largemouth bass populations in lakes use alternative methods than stocking, such as habitat restoration and predator/prey management.

Job 101.3: Evaluation of crappie stocking success in Illinois lakes and rivers.

Objectives: To determine the survival and growth of stocked crappie.

Introduction:

Supplemental stocking of a multitude of species to enhance sportfish populations has been widely used across North America (Halverson 2008). Although historical stocking of crappie has not been widespread, it has recently gained popularity for managing populations in systems with poor recruitment and high angling pressure (Isermann et al. 2002; Myers et al. 2000). The success of stocking programs for other species often hinges upon initial poststocking growth and survival, especially for juveniles (Mather and Wahl 1989; Wahl 1998). Poststocking survival has been described as a function of pre- and poststocking environment and the size, condition, genetics, and handling of stocked individuals (Isermann et al. 2002). The success of crappie stocking programs has only been evaluated by a few studies (Isermann et al. 2002; Myers et al. 2000; Myers and Rowe 2001). Post-stocking evaluations are essential for understanding the effects of the stocking program on fish populations. Furthermore, it is important to understand growth and survival of stocked fish, especially when using non-native strains.

Although black and white crappies are not commonly stocked from hatcheries in Illinois, there have been some recent examples of crappie stocking through propagation in lakeside rearing ponds. Little is known about the survival, growth and contribution of these stocked fish to the adult population and their benefits to the fishery. Blacknose black crappie (hereafter blacknose crappie) have been used in recent stockings in an attempt to evaluate the success of crappie stockings. Because of the need to differentiate stocked from naturally produced individuals in order to evaluate stocking success, management agencies began culturing blacknose crappie, a phenotypic variant of *P. nigromaculatus* (Isermann et al. 2002). Blacknose crappie are characterized by a dominant predorsal black stripe and have been found to occur naturally in at least 13 states, from Wisconsin to Florida (Buchanan and Bryant 1973; Gomelsky et al. 2005). The production and use of blacknose crappie for stocking programs has been proliferated by the Tennessee Wildlife Resource Agency (TWRA), who initially obtained their broodstock from a black crappie population in Beaver Lake, Arkansas with a high occurrence of the blacknose trait (Isermann et al. 2002). Continued use of blacknose crappie by the TWRA and other agencies has occurred not only for identification purposes, but also because of perceived increased survival and growth in hatchery environments, although these claims have not been formally evaluated (M. Smith, TWRA, personal communication). From this hatchery strain, the TWRA has supplied blacknose crappie to other states for stocking purposes, including Illinois.

Most evaluations of stocking success in crappie use oxytetracycline (OTC) to mark stocked fish for future identification (Conover and Sheehan 1996; Isermann et al. 1999; Isermann et al. 2002; Racey and Lochmann 2002). The retention rate for OTC marks is high (Conover and Sheehan 1996; Isermann et al. 1999; Isermann et al. 2002; Racey and Lochmann 2002), but identification of stocked fish marked with OTC is labor intensive and requires that the fish is killed and the otoliths removed and examined under a scope with an ultraviolet light source. Because blacknose crappie can be easily identified, they have been used as a mark in studies evaluating stocking success and OTC mark efficacy (Isermann et al. 1999), but this requires that blacknose crappie are not present in the lake and previously stocked blacknose crappie are not reproducing. In addition, not all blacknose crappie produced in ponds retain the mark potentially further confounding their use in stocking (Isermann et al. 2002; Parsons and Meals 1997). There is need to evaluate stocking success of crappie in Illinois as well as the use of blacknose crappie in studies evaluating stocking success.

The success of crappie stockings can be highly variable and first year contribution of stocked blacknose crappie was found to be lake-dependent, varying from 0 to 93% in Tennessee (Isermann et al. 2002). The contribution of stocked crappie to natural populations has been low in several studies (4.8% for black crappie, Myers et al. 2000; 0-3.8% for white crappie, Racey and Lochmann 2002). Handling mortality during stocking can contribute to low success of stocking and can account for as much as 67% mortality for white crappie (mean 23%) in the first 24 hours after stocking (Racey and Lochmann 2002). Difficulty harvesting fish from ponds was reported as a main source of handling mortality in a number of experiments rearing black crappie (Racey and Lochmann 2002; Smeltzer and Flickinger 1991; Martin 1988). Initial post-stocking mortality has been reported lower for blacknose crappie (13%; Isermann et al. 2002) and black crappie (7%; Meyers and Rowe 2001). Variable success of crappie stocking may reduce the utility of stocking to enhance crappie populations and needs to be evaluated further.

The native range of black and white crappie in North America is not well documented due to extensive transplanting across the country. Both species currently inhabit a broad range of latitudes, for black crappie from southern Canada to southern Florida and for white crappie from the Great Lakes to southern Texas. Although this indicates that both species of crappie can grow, survive, and reproduce across a broad range of latitudes, the possibility exists for thermally or latitudinally adapted strains or stocks of crappie. Blacknose crappie were genetically determined to be black crappie in terms of mapped loci used for species identification, but the strain used in stocking programs has originated from a genetically unique population in Arkansas (Gomelsky et al. 2005). Over the past several decades, the phenotype associated with the genetic identity of this strain of crappie has been selected for in TWRA hatcheries in order to produce the current strain used for stocking.

The genetic origin of a population can significantly affect its growth and survival in different environments, especially with respect to thermal conditions. Previous fisheries research has documented differences between both conspecifics from different thermal regimes (e.g. Clapp and Wahl 1996; Galarowicz and Wahl 2003; Johassen et al. 2000) and between closely related species in sympatry (Dent and Lutterschmidt 2003). Several studies have argued that genetic lineage and thermal adaptations should be considered when managing sportfish populations (Clapp and Wahl 1996; Koppelman and Phillip 1986; Phillip et al. 1981). Furthermore, a number of previous studies have found differing growth rates, survival, and genetic variability between hatchery-reared and wild strains of Salmonids (Garcia-Marin et al. 1991). In steelhead trout (*Salmo gairdneri*), hatchery strains exhibited increased growth but decreased survival when compared to wild fish (Reisenbichler and McIntyre 1977).

Differences in growth rates have been documented between white crappie and black crappie in both lake and pond environments (Buck and Hooe 1996; Jackson and Hurley 2005), but little research exists on juveniles via controlled environments. Suboptimal growth rates in crappie often lead to undesirable population demographics that are attempted to be managed by harvest regulations and/or stocking. Most systems containing both black and white crappies tend to be dominated by one of the species, although no consistent explanation exists (Sammons et al. 2002). Crappie stocking programs are becoming more common in Illinois, and the use of blacknose crappie to supplement poorly recruiting populations is gaining popularity. Although blacknose crappie have been stocked in several states, no published studies have compared their growth rates and survival with co-occurring black and white crappie populations. An evaluation of the utility of stocking black, white, and blacknose crappies in Illinois systems is needed to advise future management, especially with respect to future use of blacknose crappie.

Procedures:

Pond Experiment

We conducted pond experiments to evaluate differences in growth and survival of black, white, and blacknose crappies. For all stocking experiments, fish were produced in 0.4-ha rearing ponds at the Sam Parr Biological Station (Kinmundy, IL). Brood fish were collected from Weldon Springs Lake (Clinton, IL) and Dawson Lake (Dawson, IL) for black crappie; Lake Paradise (Mattoon, IL), Forbes Lake (Kinmundy, IL), and Sam Dale Lake (Johnsonville, IL) for white crappie; and Clinton Lake (Clinton, IL) for blacknose crappie. All brood fish were collected in the spring of 2013 via electrofishing and trap netting and approximately 40 individuals of each species were stocked into species-specific rearing ponds for production of age-0 crappie.

Growth and survival were compared among age-0 black, white, and blacknose crappies in ten drainable 0.04-ha experimental ponds at the Sam Parr Biological Station using a common garden approach. All ponds were filled with water from Forbes Lake and filtered with a 300 µm mesh sock to prevent the introduction of larval fish. Two weeks were allowed for natural colonization and development of populations of phytoplankton, zooplankton, and macroinvertebrates. Age-0 black, white, and blacknose crappies were stocked from nearby rearing ponds in August of 2013. The number of fish and biomass of age-0 fish of each species/strain was held constant for all ponds (N=50 of each species/strain, 3,750 fish/ha), within the range of natural densities of juvenile crappie (173-10,456 fish/ha)(Mitzner 1981).

Initial weight (g) and total length (mm) for each species/strain was determined based on a subsample (N=50) to reduce handling of all experimental fish. Average initial length for all age-0 crappie was 46 mm, with no statistical differences among the species/strains. After a three-month growth period, ponds were drained and final weight and total length were determined for each species/strain by measuring all fish. Survival for each species/strain was calculated as the number of fish at draining divided by the number of fish initially stocked.

All experimental ponds were also sampled to account for potential interactions between the growth and survival of each species/strain and the characteristics of a given pond. Phosphorous, chlorophyll-a, temperature, dissolved oxygen, and turbidity were sampled every three weeks, whereas zooplankton, vegetation, and macroinvertebrates were sampled every 45 days beginning with fish introduction.

Mixed model ANOVAs with fixed species and random pond effects were used to test the overall species effect on growth and survival. A Tukey's mean separation test was used to test differences in growth and survival among black, white, and blacknose crappie. Multivariate analyses were used to determine which environmental variables had the greatest effect on growth and accounted for the majority of between-pond variation. A principal component analysis (PCA) was used to reduce the number of overall variables for final analysis, utilizing the "B4-broken-stick" method for variable selection (King and Jackson 1999). Multiple linear regression analyses were used to associate growth and survival with the reduced environmental variable set. Akaike information criterion (AIC) scores were used to select the best model(s), with the best model having the lowest AIC score. Models within two AIC units of the best model were considered of equal predictive power (Burnham and Anderson 2002).

Ridge Lake

To assess the relative growth and survival of stocked black, white, and blacknose crappie at a larger scale, juvenile fish from the Sam Parr Biological Station rearing ponds were stocked into Ridge Lake (Charleston, IL) in the fall of 2013. To simulate a stocking event, 0.04-ha rearing ponds were drained, fish were collected from a catch basin via dip nets, and black (N=1,000), white (N=300), and blacknose (N=1,000) crappies were transported to Ridge Lake via hauling tanks for subsequent stocking. Average size at stocking was 60 mm and there were no significant differences among the species/strains. Lower densities of white crappie were stocked because of lower production in rearing ponds.

Ridge Lake was sampled to determine the relative growth and survival of the stocked crappie species/strains. Sampling included biweekly seining in the littoral zone during the spring and summer, as well as AC boat electrofishing twice in the spring and fall.

Illinois River

In this segment, we evaluated blacknose crappie stocking in the Starved Rock pool of the Illinois River. Blacknosed crappie brood stock were collected from Clinton Lake in the spring of 2013 and transferred to the Jake Wolf Memorial Fish Hatchery. Brood fish were placed in rearing ponds to produce fish for stocking. In fall of 2013, blacknose crappie were stocked into the Illinois River into the Marseilles pool just above the dam. We conducted electrofishing sampling as well as 10 net nights of fyke netting and 10 net nights of mini fyke netting to assess survival of the stocked fish. We will evaluate the success of the stocking and determine if blacknose crappie stocking in the Illinois River has the potential to create a new fishery.

<u>Findings</u>:

Pond Experiment

Percent survival of stocked age-0 crappie was slightly variable by pond (Figure 101.2). The percent survival of each species/strain was 63% for black crappie (SE = 5.4), 66.4% for blacknose crappie (SE = 4.1), and 67% for white crappie (SE = 3.4). Average survival for all species/strains was 65.5%, and no significant differences were observed among the species/strains (ANOVA, F = 0.35, P = 0.71)(Figure 101.3 A). Overall adjusted change in length for each species/strain was 53.3 mm (SE = 2.4) for black crappie, 57.3 mm (SE = 2.4) for blacknose crappie, and 52.2 mm (SE = 2.4) for white crappie. Change in length was variable by pond (Figure 101.4) and a significant species effect was observed, with blacknose crappie growing more in length than both black and white crappies (ANOVA, F = 11.85, P = 0.0005; Figure 101.3 B). Overall adjusted change in weight for each species/strain was 11.4 g (SE = 1.12) for black crappie, 12.9 g (SE = 1.12) for blacknose crappie, and 9.2 g (SE = 1.12) for white crappie. Change in weight was also variable by pond (Figure 101.5) and a significant species effect separated all three species/strains, with blacknose crappie gaining more weight than black crappie and black crappie gaining more weight than white crappie (ANOVA, F = 25.0684, P = <0.0001)(Figure 101.3 C).

Ponds were fairly diverse in terms of the environmental variables measured (Table 101.2). Prior to multivariate analyses, all environmental variables (N=10) were transformed to meet assumptions of normality (square root transformation) except natural log transformation for rotifer density and reciprocal transformation for turbidity. Variable selection via PCA yielded a reduced variable set (N=3) including turbidity, phosphorous, and total zooplankton density.

Multiple linear regression analysis was performed on change in weight for each species (change in length followed the same trends) and all possible models including the reduced subset of variables were compared via AIC scores. The best model for black crappie included total zooplankton density, turbidity, and an intercept ($R^2 = 0.80$), with two alternative models being within two AIC units (Table 101.3). The best model for blacknose crappie included just total zooplankton density ($R^2 = 0.96$), with four alternative models being within two AIC units (Table 101.3). Similarly, the best model for white crappie included only total zooplankton density ($R^2 = 0.95$), with three alternative models being within two AIC units (Table 101.3). Linear regression analyses indicated positive relationships between total zooplankton density and change in weight of black ($R^2 = 0.60$), white ($R^2 = 0.56$), and blacknose ($R^2 = 0.48$) crappies. Linear regression analysis did not indicate a relationship between change in weight and turbidity or phosphorous for any of the species/strains ($R^2 < 0.1$ for all relationships). Total zooplankton density was also highly negatively correlated with total macroinvertebrate density ($R^2 = 0.49$, $P < 0.0001$) and total vegetation density ($R^2 = 0.63$, $P < 0.0001$). Multiple linear regression analysis was not performed on percent survival using environmental variables because no significant pond effect was detected (ANOVA, $P = 0.38$).

Ridge Lake

Spring and early summer sampling have not detected any stocked crappie in Ridge Lake. This could be due to a lack of overall survival or an invulnerability of juvenile crappie to our current gear types. Sampling and monitoring of the crappie population in Ridge Lake will continue in the fall of 2014 and spring of 2015 as the fish become more susceptible to electrofishing. We will also begin using an experimental mid-water trawl in the late summer and fall of 2014 to try to detect crappie that other gears are potentially missing.

Illinois River

Blacknose crappie were stocked into the Illinois River to assess if a river fishery could be created through stocking. On September 26, 2013, a total of 6619 of approximately 3 inches (50.6 fish/pound) were released into the Marseilles pool of the Illinois River, just upstream of the Marseilles dam in the side channel near Ballard's Island. We returned to the stocking location one month following stocking and conducted 10 net nights of crappie fyke netting and 10 net nights of mini fyke netting as well as conducted electrofishing transects. Sampling was divided between the side channel where the fish were stocked and the main channel of the Illinois River above and below the stocking location. A total of 291 fish were caught in the fyke and mini fyke nets and a total of 839 fish were collected in electrofishing samples. Fish collected were similar in size to the estimated size of the stocked fish (3-5 inches). None of the stocked blacknose crappie were recaptured. Although fyke and mini fyke nets are the preferred method for capturing young-of-year crappie, we have observed low catch rates in these gears in Illinois Lakes (see Job 104.3). We have begun using trawl sampling and have had success collecting juvenile crappie in greater numbers. In the next segment, we will return to the stocking location and conduct bottom and midwater trawls using an electrified trawl to determine if any of the stocked fish have survived at a high rate. However, data from shortly after the initial stocking suggests that these fish have not survived. We will conduct additional sampling to determine if any of the stocked crappie survived the winter. We will conduct additional sampling in order to evaluate the potential for these stockings to create a viable fishery.

Recommendations:

Experimental ponds suggest that species/strain is an important factor determining growth of juvenile crappie. Blacknose crappie grew faster than black and white crappies in both length and weight. Black and white crappies were the same length at the end of the experiment, but black crappie put on significantly more mass. Differences in length-weight relationships between black and white crappies have been observed in previous research, but these differences have not been examined in the juvenile life stage via controlled experiments. Furthermore, no previous studies have compared blacknose crappie growth with that of black and white crappies at any life stage. Despite these observed differences in growth among the three strains, there were no significant differences in overall survival over the three-month experiment. No pond effect was observed with respect to survival, suggesting that initial post-stocking mortality (i.e. handling-induced mortality) may have been the driving factor.

Between-pond variation in growth rates was driven primarily by total zooplankton density. Our multivariate analyses yielded alternative models for predicting juvenile crappie growth that included turbidity and/or phosphorous for all species/strains, but further evaluation of relationships between growth and turbidity and phosphorous were unconvincing. Total zooplankton density was negatively correlated with total macroinvertebrate density (mainly dipteran larvae) and vegetation density, with ponds having high zooplankton density, low macroinvertebrate density, and low vegetation density having the fasted growth rates. Previous research has suggested differences in preference for environmental characteristics between black and white crappies (i.e. turbidity, vegetation). We did not detect any species-environment interactions in our experimental ponds, but a more manipulative design may be required to tease out differing effects of environmental variables on each species/strain. Any species differences may also not be apparent until later life stages.

Our findings suggest that blacknose crappie have the potential to outgrow both black and white crappie at least at the juvenile stage. Size and body condition at the end of the first growing season has been shown to influence overwinter mortality in numerous species via starvation, predation risk, osmoregulatory failure, etc. (Sogard 1997). Further research is needed to evaluate whether this higher growth potential translates to increased survival in larger systems or accelerated growth to desirable sizes. In largemouth bass (*Micropterus salmoides*), our previous research indicates the need to evaluate long-term stocking success (INHS Technical Report 2011). We will continue to evaluate the survival and growth of black, white, and blacknose crappies in Ridge Lake to evaluate the long-term stocking success of the three strains in a larger system. In addition, we will continue to evaluate blacknose crappie stocking in the Illinois River. At this time we have no evidence of survival of stocked crappie at either Ridge Lake or the Illinois River. Young-of-year and juvenile crappie populations have successfully been assessed in a number of studies in natural lakes and fyke nets are the preferred method to conduct this sampling. Our results from crappie fyke netting in Job 104.3 suggests low numbers of age-0 and age-1 crappie in both spring and fall fyke netting efforts. Some additional studies have had success sampling smaller sizes of crappie using a mid-water trawl. We have begun experimenting using a mid-water and a bottom electrified trawl and have begun catching young-of-year and age-1 crappie in higher numbers. These crappie appear to be selecting open water habitats in Illinois reservoirs and therefore may not be vulnerable to shoreline sampling using fyke nets. In the next segment, we will compare different trawling methods and locations to determine the best strategy for capturing small crappie. We will conduct trawling efforts in addition to electrofishing transects in Ridge Lake and the Illinois River to attempt to recapture stocked crappie. Because of the difficulty capturing young-of-year and age-1 crappie in other systems, we believe it is too soon to evaluate the stockings. However electrofishing and fyke net sampling to date suggest the stocked crappie did not survive at high rates. Additional sampling is required in order to further evaluate stocking success.

Job 101.4: Effect of hatchery forage type on survival and growth of stocked largemouth bass.

Objectives: To compare various rearing techniques on stocking success for largemouth bass.

Introduction:

In previous segments of this study, we have evaluated various aspects of largemouth bass stocking success with the goal of increasing survival and growth. We examined the potential benefits of stocking larger fish by comparing the stocking success of four sizes of largemouth bass (Diana and Wahl 2009), but found no differences in survival and growth of 4, 6, and 8 inch fish. We recommended stocking four inch fish based on cost benefit analyses and the lack of survival of larger fish. We also evaluated different rearing techniques by comparing growth and survival of largemouth bass produced in raceways to those produced in rearing ponds (Diana et al. 2011). Although initial survival and growth of extensively reared fish was significantly higher, long-term survival was low and no differences in rearing technique were observed. Additional research is needed to improve long-term survival of fish produced in rearing ponds perhaps through predator or prey acclimation. Despite low long-term survival of stocked fish, using genetically marked fish we were able to verify that stocked fish are successfully spawning and contributing to young-of-year production (Diana et al. 2011). There is a continued need to attempt to increase survival of stocked largemouth bass by identifying the factors limiting their long-term survival. In Job 101.1, we have been comparing point versus dispersed stocking of largemouth bass and observed continued low survival of stocked largemouth bass using a variety of stocking and rearing techniques. In order for stocking largemouth bass to be a viable management technique, there is a need to increase the number of fish surviving in the wild and contributing to the fishery. Diet analysis of fish stocked as part of previous studies have shown stocked largemouth bass experiencing difficulty preying on fish in the 2 months following stocking resulting in low growth (Diana and Wahl 2009; Diana et al 2011). Tank experiments with these fish showed that hatchery largemouth bass had difficulty capturing bluegill prey and expended more energy chasing this novel prey type (Diana et al 2011). If stocked fish are struggling switching to foraging on fish, especially Centrarchid prey which constitute a large portion of the prey base and are elusive, there may be an advantage to acclimating them to this prey prior to releasing them at stocking. In this study, we will initiate lab and pond experiments to evaluate the value of different forage type fed to stocked largemouth bass in hatchery ponds. Largemouth bass fed pelleted food will be stocked from the Jake Wolf Fish hatchery at the smallest size they are available. Ponds will be separated into treatments and fed different prey types. Prey will consist of a typical feed for hatchery ponds, fathead minnows, or prey more commonly found in Illinois reservoirs, bluegill. Largemouth bass will be raised in the ponds until the fall, when they will be stocked into selected experimental ponds and eventually into Illinois lakes. Prey capture ability of fish reared on the two forage types will be assessed in laboratory behavioral experiments. We will examine differences in growth and survival of fish fed with the two prey types in ponds as well as following stocking in lakes. Examining rearing strategies and feeding stocked fish more natural prey prior to stocking will allow us to determine if experience with natural prey can increase feeding ability of stocked fish once introduced into the wild. Results from these studies will be used to adjust stocking methods to increase contribution of stocked fish to the natural population and improve largemouth bass fisheries in Illinois.

Methods:

Tank Experiments

We examined behavior of hatchery-reared largemouth bass foraging on fathead minnow or bluegill in laboratory experiments. Largemouth bass (100-130 mm total length) were obtained from the Jake Wolf Memorial Fish Hatchery in Manito, IL and held in stream tanks at densities similar to hatchery conditions. Groups of 20 fish were measured for total length and immediately divided into one of three treatment groups each fed daily on a maintenance ration of pellets, fathead minnow, or juvenile bluegill for one month.

Prior to experiments, individual largemouth bass were starved for approximately 42 hours, measured (nearest TL), and acclimated overnight in 1-m diameter blue tanks (28 cm depth). Tanks had the bottom covered in white sand (2 cm) to facilitate contrast between the fish and tank bottom for videotaping. One hour prior to the start of experiments, groups of five single-species prey (fathead minnow or bluegill) were measured (nearest TL) and held within a container placed into the tank with the largemouth bass. To standardize prey size and account for differential prey morphology, fathead minnow ranged from 37-41% and bluegill 28-32% of predator size, based on previous experiments examining foraging of juvenile largemouth bass. Juvenile bluegill for experiments were seined from local ponds containing largemouth bass predators. Fathead minnow were obtained from a bait dealer and co-resided with a predatory largemouth bass in a 700 L laboratory holding tank to ensure exposure to a predator.
Prey were acclimated for one hour in the experimental tanks and then released and largemouth bass were allowed to forage for two hours. Behaviors recorded included predator follow distance, number of follows, strikes, and captures, and after a capture, whether the prey was eaten, spit out, or escaped. We also recorded the time (s) from the start of an experiment to initial capture of an ingested prey and time spent moving (either foraging or swimming randomly) within the experimental tank. Capture efficiency was calculated as number of captures divided by the number of strikes. Using 60 largemouth bass, we completed 10 replicate experiments for each largemouth bass treatment group (pellet, fathead minnow, or bluegill ration) and prey group (fathead minnow or bluegill), for a total of 60 experiments. Differences among treatments were tested using a 2-way ANOVA and significant treatment effects were examined using LS Means.

Pond Experiments

In this segment, we also initiated pond experiments to compare growth and survival of largemouth bass fed three prey types. Four 1/3 acre ponds and six 1-acre ponds at the Sam Parr Biological Station were drained and filled in spring to prepare for initial setup of the experiment. The four 1/3 acre ponds were established as prey acclimation ponds and two were stocked with 10 breeding pairs of adult bluegill and two were stocked with fathead minnows one month prior to the introduction of hatchery largemouth bass. These prey fish were allowed to spawn in order to produce bluegill and minnow prey of optimal size for largemouth bass. Three-inch pellet reared largemouth bass will be provided by the Jake Wolf Memorial Fish hatchery and will be stocked at a density of 750 fish per pond. The stocked largemouth bass will be allowed to forage on the provided prey for one month. At this point the ponds will be drained and we will receive additional pellet reared fish from the hatchery (~4 inch). We will mark the three types of largemouth bass (fathead minnow fed, bluegill fed, and pellet reared) with distinct marks using elastomer dye and stock them into the 1 acre ponds at a target density of 150 fish of each rearing type per pond. The six one acre ponds were established as experimental ponds by stocking each pond with 22 female and 18 male breeding adult bluegill. These bluegill will be allowed to spawn to produce prey of optimal size for the stocked largemouth bass. We will compare growth and survival of the three feeding regimes of stocked largemouth bass over a two month experiment to evaluate the best rearing strategy. We will conduct diet analysis of the three types of largemouth bass periodically throughout the experiment to confirm they are eating the provided prey and evaluate differences among the three types.

<u>Findings</u>:

Tanks Experiments

Prior to experiments, largemouth bass in all treatment groups were similar in length (overall mean = 127.5 mm TL; $P = 0.06$). We found few differences in foraging behaviors among treatment groups and no significant interactions between treatment group and prey type were found ($P > 0.19$). All treatment groups had similar number of prey captures leading to consumption ($P = 0.32$). There were differences in number of follows ($P < 0.003$) and prey captured ($P = 0.0002$) among treatments. Largemouth bass raised on fathead minnow prey were slightly more active and followed prey more often, taking more strikes on prey compared to bluegill or pellet-reared largemouth bass (Figure 101.6). Increased activity resulted in more overall prey captures ($P = 0.009$). There were significant differences in prey escapes among treatment groups ($P = 0.004$). Largemouth bass reared on fathead minnow had significantly more prey escapes than the other two treatment groups. Initial time to capture for an ingested prey was similar among treatment groups ($P = 0.94$), and largemouth bass in all groups spent a similar amount of time moving within the tank ($P = 0.82$).

While number of captures on bluegill and fathead minnow were similar ($P=0.25$), capture efficiencies on bluegill were lower than fathead minnow for all treatment groups (Figure 101.7; $P = 0.01$). Largemouth bass also had more follows and longer follow distances on bluegill compared to fathead minnow ($P < 0.03$). This was expected as bluegill have been shown to be a more elusive prey type, however fish acclimated on bluegill prey did not show an advantage in experiments while feeding on bluegill prey. Low numbers of replication in this study ($n = 10$) may make it difficult to detect differences. We will conduct additional replications in the next segment to further evaluate the potential of prey acclimation to benefit stocked largemouth bass growth and survival.

Pond Experiments

Seine hauls from the two bluegill rearing ponds indicated that the parental bluegill successfully spawned and young-of-year bluegill were an average of 20 mm total length and size at a density of 4.4 fish per m^3. The size of young-of-year fish in the ponds ranged from 10-30 mm and should all be vulnerable to the stocked largemouth bass. Densities of fathead minnows in the rearing pond were 7.6 fish/m^3 and 7.1 fish/m^3 and densities in the bluegill ponds were 4.4 fish/m^3 and 4.4 fish/m^3. We will stock hatchery largemouth bass into these ponds in the next segment, allow them to feed in the rearing ponds for one month, and then initiate the experiment and report findings in the next report.

<u>Recommendations</u>:

We are in the initial phases of evaluating prey acclimation as a method of enhancing stocked largemouth bass growth and survival. We have not observed many differences in feeding ability of fish reared with bluegill compared to those reared with minnows and pellets. Preliminary results suggest that minnow reared largemouth bass are more active when chasing prey, resulting in more strikes and captures of prey, however this does not result in more prey consumed as they commonly spit out the prey or kill the prey fish rather than consuming them. At this time, there is not enough replication in the tank experiments to evaluate differences in foraging and we will conduct additional experiments in the next segment and report additional findings. Pond experiments have been initiated and should allow us to further evaluate these rearing strategies in a more natural setting. Stocked largemouth bass that are reared on pellets have no experience with natural prey types and may have difficulty feeding on fish once stocked in the wild. Generally largemouth bass of similar sizes in the wild have switched to fish prey and we have demonstrated in previous research that the timing of the switch to fish prey is an important variable in determining survival of largemouth bass in the wild (Diana et al 2011; Parkos and Wahl 2010). Stocked largemouth bass that have been reared in ponds and fed minnows have been shown to have some increases in growth and survival compared to pellet reared fish, but they do not have experience foraging on more natural prey such as bluegill and gizzard shad. We will continue to evaluate alternate rearing techniques for largemouth bass to determine if survival and growth can be enhanced through natural prey acclimation. We will use this information to make recommendations regarding rearing techniques and potentially test these ideas in lake stockings in future segments.

Study 102: Harvest, Regulations, and Tournaments

Job 102.1: Evaluation of effect of largemouth bass harvest regulations on population structure in Illinois lakes.

Objectives: To evaluate the effects of various angling regulations on Illinois bass recruitment and size structure.

Introduction:

Angling is a popular recreational activity where fish are caught and either released, or harvested for food. Unregulated harvest of fish populations can result in overexploitation resulting in undesired density or size of fish. Harvest regulations are one of the more common management tools utilized to maintain or improve sport fisheries. However, changes in fish populations as a result of a regulation are rarely assessed. When regulations are assessed, they are generally in one lake or are not long-term enough to adequately measure changes in size structure and abundance. Regulations must be obeyed and require both angler cooperation and enforcement by conservation police in order to be successful. In addition, these regulations require harvest rates great enough to produce the desired effect. Largemouth bass are commonly released after capture and the general fishery is more catch-and-release oriented.

Angling regulations are a commonly used management tool for sustaining or improving sport fish fisheries. Increasing the quality of angler catch or harvest rates are common rationales for harvest regulations (Paukert et al. 2007). However, compilation of 91 studies using minimum-length limits and slot-length limits concluded that most studies evaluating regulations were conducted over too short a period and did not include creel data to document if a regulation increased angler catch rates (Wilde 1997). Both recruitment variation and the length of the evaluation can influence the ability to detect changes in a fish population due to a regulation (Allen and Pine 2000). Crappie and largemouth bass are commonly managed using minimum length limits (Buynak et al. 1991; Colvin 1991; Webb and Ott 1991; Wilde 1997; Maceina et al. 1998), but a wide variety of other regulations are also being used in Illinois. Potential regulations include bag limits, maximum size limits, minimum size limits, slot limits, bag limits that vary by the size of the fish, and catch-and-release only. Many of these regulation types are even less understood and there is a need for evaluation across a number of lakes and species.

A wide variety of largemouth bass regulations have been utilized to manage their populations. The most commonly used regulations are minimum size and protected slot limits (Wilde 1997; Paukert et al. 2007). The goals of using minimum size and slot limits include increasing abundance and size structure of largemouth bass resulting in an increase of larger fish available for anglers (Anderson 1976; Eder 1984; Dent 1986; Redmond 1986; Richards 1986). Length limits are the most common regulation for largemouth bass and are designed to allow a fish to spawn at least once before being harvested and reduce overall harvest (Redmond 1986). Slot limits have been utilized when largemouth bass populations are extremely slow growing and there is an overabundance of small fish (Anderson 1976; Eder 1984). Slot limits allow the harvest of small fish while protecting fish that have grown out of the crowded size class, yet still allowing anglers to harvest larger fish. Both of these regulations have associated bag limits where the total number of fish harvested is limited to a certain number to avoid overexploitation. Case studies of these regulations have shown variable success and when examined in a meta-analysis, protected slot limits were more effective at increasing size structure, while minimum size limits increased catch rates (Wilde 1997). There have been many examples of minimum size limits maintaining or increasing growth or catch of largemouth however often times growth can decrease and abundance of desired size of fish does not improve (see Wilde et al. 1997). Largemouth bass regulations often do not achieve the desired changes and without monitoring and evaluation could cause undesired effects. In order for regulations to be effective, managers need to have specific goals that incorporate the recruitment, growth and mortality of largemouth bass and conduct studies to evaluate changes (Novinger 1984; Johnson and Martinez 1995). Many regulation decisions are not influenced by information available on black bass biology (Paukert et al. 2007). There is a need for further research examining the effects of angling regulations (Novinger 1984; Wilde 1997; Paukert et al. 2007). In previous studies, we began to compile data on a number of regulations. In the current study, we continue to expand the database and evaluate the use and success of the different regulation employed in Illinois. We will provide management recommendations based on the results of this analysis that can help guide future management.

Procedures:

We evaluated largemouth bass regulations utilized in Illinois lakes. In this segment, we examined a time series of regulations in order to determine how largemouth bass populations are changing due to regulation changes. We obtained all regulation booklets from the IDNR that were available in an electronic format (2007 – 2014). We are continuing to coordinate with the IDNR to obtain paper copies of regulation booklets prior to the use of digital formats. A time series of regulations was created for 2007 through 2014. Lakes were categorized using their existing regulations into nine categories, over/under (bag limit above and below a specified size), catch-and release (no harvest allowed), standard (14" length limit, 6 fish creel), lowered bag (14" length limit, < 6 fish bag limit), lowered Length (<14", 6 fish creel), raised length (>14" length limit, 6 fish bag limit), raised length/lowered bag (> 14" length limit, < 6 fish bag limit), no length (no minimum size limit, 6 fish bag), and slot (no harvest slot). In addition lakes were categorized as changed if the regulation was altered at any point from 2007 through 2014 or constant if the regulation did not change. We compiled data collected by Illinois DNR biologists using electrofishing samples from 2007 through 2013. Data was only included in the analysis if it was sampled using AC shoreline electrofishing conducted in the years where time series regulation data was available. These lakes were then compared across regulation type for differences in CPUE of young-of-year largemouth bass, CPUE of largemouth bass greater than 14 inches, and proportional stock density (PSD) with stock size being 200 mm and quality size being 300 mm. In addition we determined the number of preferred (> 379 mm and < 510 mm) and memorable (>510 mm) sized fish in electrofishing samples. Mean catch rates were compared across regulations types in lakes where regulations had not changed throughout the study period in order to evaluate populations where a regulation has been in place long enough to affect a population. In addition, we analyzed lakes with regulation changes by comparing catch rates and size structure before and after a regulation change. We used ANOVA to determine if there were any significant differences in catch rates among the different regulations for each size class of largemouth bass.

Findings:

We summarized 7 years (2007 – 2013) of FAS data to evaluate electrofishing catch rates and size structure of largemouth bass among differing management regulations. A total of 268 lakes were sampled at least one time by IDNR biologists using electrofishing in 2007 – 2013. Regulation data was then compiled from the Illinois Department of Natural Resources (IDNR) fishing regulations guide for these same lakes resulting in a total of 488 lakes with regulation data. Regulations were grouped into 9 categories (Table 102.1). The most common regulation was that of no length limit with a 6 fish bag limit. These are the default regulations in place if there is no specified regulation in the Illinois fishing guide and most lakes are not being managed differently than the default. The second most common regulation type was the raised length and lowered bag limit. When biologists are imposing regulations on a lake in an attempt to manage largemouth bass populations, they tend to impose more restrictive regulations probably due to a perceived problem with the fishery. The standard regulation is the third most common regulation with a 14-inch length limit and 6 fish bag limit. Slot, lowered bag, catch and release, and raised length limits were utilized the least in Illinois.

A total of 426 lakes had the same regulation in place from 2007 – 2013 and 159 of these lakes had electrofishing data in the FAS database and could be the analyzed for changes. We examined differences in largemouth bass catch rates among 6 of the 9 different regulations. Lowered Length, Over/under, and catch and release regulated lakes were removed from the analyses due to the low number of lakes in these treatments with FAS data ($n = 2$). Despite the different regulation types on Illinois lakes, there were few differences in largemouth bass populations among regulation categories. There were significant differences in total CPUE of largemouth bass among regulation types ($F = 5.13$; $P = 0.0002$) with Slot limit lakes having significantly greater CPUE than all other regulation types ($P < 0.05$) except Raised Length limits ($t = 2.03$; $P = 0.33$) that were intermediate (Figure 102.1). There were also significant differences in CPUE of young-of-year largemouth bass (5.02; $P = 0.0003$) that drove the differences in total CPUE (Figure 102.2). Slot regulations had the highest number of young-of-year largemouth bass and CPUE was significantly greater than all other regulation types except Lowered Bag ($t = -1.67$; $P = 0.55$) and No Length ($t = -2.17$; $P = 0.26$). There were no significant differences in CPUE of young-of-year among any other regulation types. There were no differences among regulation types in CPUE for largemouth bass over 14 inches ($F = 1.16$; $P = 0.33$), preferred size ($F = 1.00$; $P = 0.42$), or memorable size ($F = 1.71$; $P = 0.14$; Figure 102.3). Slot limits and Raised Length limits had the highest CPUE for all three adult size classes examined, but due to variation among lakes, differences were not significant.

A total of 62 lakes experienced a change in regulations from 2007 through 2013 (Table 102.1). The primary change in regulation was adding raised length and lowered bag limits to lakes that previously only had the state wide bag limit in place ($n = 25$). For the most part, regulation changes resulted in a more restrictive regulation than prior to the change. Of the lakes with regulation changes, only 20 were sampled by the IDNR in the period from 2007 to 2013. Of the 20 lakes, only 6 had IDNR samples conducted both before and after the regulation, all with different regulations, limiting our ability to test for differences.

Recommendations:

There are many potential harvest regulation strategies that can be used to help manage sportfish populations, including size limits, closed seasons, and spawning refuges. Each of them can have a different impact on the population, either by affecting size structure or density. Some regulations have the potential to impact recruitment more than others, but right now, we cannot make accurate predictions. This study has begun to provide information on the success of regulations on largemouth bass populations throughout Illinois. Regulations vary greatly in

Illinois reservoirs. Our analyses have shown some differences in largemouth bass populations among regulation types. In particular, slot limits have significantly greater young-of-year fish than most other regulation types with the total catch rate being higher, but no difference among adult size classes. It is unclear if slot limits are resulting in high recruitment and a high abundance of young-of-year largemouth bass or if slot limits are in place as a result of the overabundance of small fish. Slot limit lakes did have the highest abundance of adult largemouth bass of 14-inches and greater, preferred, and memorable sizes, but there is also large variation in catch rates in these lakes. Slot limit lakes have very similar catch rates of larger adult largemouth bass as raised length limit lakes. These two regulation types both have an increased size structure in which the larger fish are protected at (greater than 14 inches) which may be resulting in greater abundance of larger fish. In slot limit lakes, harvest of smaller fish is allowed yet anglers may not harvest many of the smaller individuals resulting in no differences with other regulation types. CPUE of young-of year largemouth bass is also the greatest in slot limit lakes and was also higher in the lowered bag limit lakes. Both of these regulations may be reducing overall harvest resulting in greater numbers of largemouth bass below the preferred harvest size and resulting in higher recruitment.

We expected to find some differences among lakes that are not intensively managed and those with restrictive regulations. Slot limits are in place to protect fish in a vulnerable size class and fish density should be different than lakes that do not have these regulations. There is a good deal of variation among largemouth bass populations over the 7 year period both within lakes and among those with similar regulations and could mask differences among regulation types. In addition, we do not know the level of harvest of largemouth bass in these lakes. Catch and release angling is very common for largemouth bass, but many regulations require some level of harvest to be successful (e.g. slot limits). If restrictive regulations do not reduce the level of harvest either because anglers are not compliant or little harvest occurs regardless of the regulation, differences among regulations would not be observed. Future segments will explore the role of harvest of largemouth bass and how harvest differs among lakes with differing regulations.

Future analyses should expand the time series data to determine how populations change as regulations are implemented. We will attempt to increase the number of years we are examining to include more IDNR data and additional lakes with regulation changes. Data before and after regulation changes should be examined and the length of time a regulation has been implemented will be evaluated. We will continue to incorporate lakes with FAS data and INHS sampling to develop a long term database of lakes with fish community data and creel sampling. The number and frequency of lakes where angling creels were performed will limit the number of lakes that can be included in this aspect of the study. We will continue to create an extensive database that can be used to examine differences in electrofishing catch. We will contact DNR district biologists and determine when regulations were initiated and use creel and FAS data to compare catch rates of anglers, CPUE from electrofishing and size structure of largemouth bass in these lakes before and after the regulation were in effect. In doing so, we hope to better understand the value of differing management regulations on lakes throughout Illinois. These data can then be used to guide future discussions about various management experiments that might be implemented.

Job 102.2: Evaluation of crappie harvest regulations in Illinois lakes.

Objectives: To evaluate the success of current harvest regulations in managing for or maintaining quality crappie fisheries in Illinois.

Introduction:

Crappie anglers primarily fish for harvest and release is limited to small fish or those protected by a regulation. Differences in regulation types and their success can be expected between crappie and other sportfish species such as largemouth bass. There are a large variety of angling regulations on lakes throughout Illinois and very few statewide guidelines for a lake are available for management regulations of these species. There is a need for studies involving multiple lakes with long-term databases to determine the success of different types of regulations throughout the state of Illinois. This study will provide data for use in developing regulation standards and guidelines for Illinois.

Crappie regulations were rarely used for crappie populations prior to 1990 because of the worry of limited harvest leading to high densities of stunted fish (Mitzner 1984; Webb and Ott 1991). Managers began more recently to incorporate minimum length limits to lower fishing mortality and protect larger fish (Bister et al 2002). Minimum length limits have been shown to increase the catch rates of larger crappie as well as mean size in some systems (Colvin 1991; Webb and Ott 1991). However, limiting harvest can cause adverse effects if prey resources are limited or natural mortality is high (Colvin 1991; Larson et al. 1991; Reed and Davies 1991; Allen and Miranda 1995; Hale et al. 1999; Bister et al. 2002). Crappie regulations can be difficult to evaluate because of the high variation in recruitment (Colvin 1991; Maceina et al. 1998; Allen and Pine 2000). A number of additional regulations exist for crappies in Illinois that have not been as well studied, including size specific bag limits. Size specific bag limits control the number of fish that can be harvested both above and below a particular size. There is a need for evaluation of regulations currently in use in Illinois using long-term data on multiple lakes.

Procedures:

In this segment, we conducted similar analysis as that in Job 102.1 for crappie regulation in Illinois. Crappie regulations were summarized from IDNR fishing regulation booklets that were available in an electronic format (2007 – 2014). We are continuing to coordinate with the IDNR to obtain paper copies of regulation booklets prior to the use of digital formats. A database including a time series of regulations was created for 2007 through 2014. Lakes were categorized based upon the type of regulation into six different categories including Bag limits (any regulation limiting only the number of fish harvested), catch and release (no harvest allowed), Length Limits (only the size of fish harvested in regulated), Length and Bag Limits (minimum size limit and bag limit), over/under (harvest limited to a certain number above and below a specified size), and lakes with no regulations. In addition, lakes were categorized as changed if the regulation was altered at any point from 2007 through 2014 or constant if the regulation did not change. We compiled data collected by Illinois DNR biologists using electrofishing samples from 2007 through 2013. Data was only included in the analysis if it was sampled using shoreline electrofishing conducted in the years where time series regulation data were available. Because regulations do vary between white and black crappie, we calculated catch rates and size structure for the two species combined. These lakes were then compared across regulation type for differences in CPUE for all crappie, CPUE of young-of-year (< 130 mm), preferred size (250 – 299 mm), memorable size (300 – 379 mm), and trophy size (> 380 mm) in electrofishing samples. Mean catch rates were compared across regulations types in lakes where regulations had not changed throughout the study period. In addition, we analyzed lakes with regulation changes by comparing catch rates and size structure before and after a regulation change. We used ANOVA to determine if there were any significant differences in catch rates among the different regulations for each size class of crappie species.

Findings:

We summarized 7 years (2007 – 2013) of FAS data to evaluate electrofishing catch rates and size structure of black and white crappie among differing management regulations. Of the 488 lakes with posted regulations in the Illinois regulation booklet, 135 were sampled at least one time by IDNR biologists using electrofishing in 2007 – 2013. Regulations were grouped into 6 categories (Table 102.2). A majority of lakes in Illinois have no harvest regulations imposed for crappie in 2013 (n = 380). The most common regulations in place in 2013 were Length and Bag limits followed by Bag limits alone. Only one lake had either catch-and-release or length only limits in 2013 and these lakes were excluded from analyses.

A total of 439 lakes had the same regulation in place from 2007 – 2013 and 125 of these lakes had electrofishing data in the FAS database and were used in the analysis comparing regulations. Over/Under regulations had the highest total CPUE as well as the most preferred and memorable fish; however these only had been in place on two lakes for the entire study period and was excluded from analyses. The one lake with a catch-and-release regulation had the greatest CPUE of young-of-year crappie, but very few larger fish. Catch-and-release regulations are commonly put in place when stocking a system following a fish kill or when setting up a new fishery and may explain the abundance of small fish and lack of memorable sized crappie and the lake was also excluded from the analysis. We examined differences in largemouth bass catch rates among the 3 most common regulations, Bag, Bag and Length, and No regulation. Length and bag limit lakes exhibited the highest total CPUE followed by unregulated lakes, then bag limit only lakes, but there was no significant differences among regulation types ($F = 0.69$; $P = 0.50$; Figure 201.4). Across all lakes, very few young-of-year crappie were collected with electrofishing gear (see Job 104.3). Catch rates of larger crappie were also low among study lakes (Figure 102.5) and there was no significant difference in CPUE of preferred size ($F = 1.65$; $P = 0.20$), memorable size ($F = 0.32$; $P = 0.73$), or trophy size crappie ($F = 0.16$; $P = 0.85$). Because of the variation in length and bag limits, we did not compare within these regulations. We will expand the database in future segments to further examine the effects of different length and bag limits.

A total of 49 lakes experienced a change in crappie regulations from 2007 through 2013 (Table 102.2). The primary change in regulation was adding a bag limit to unregulated lakes (n = 15) followed closely by changing length and bag limit regulations to an over/under regulation (n = 14). For the most part, regulation changes resulted in a more restrictive regulation than prior to the change although regulations were removed on 4 lakes. Of the lakes with regulation changes, only 10 were sampled by the IDNR in the period from 2007 to 2013 both before and after the regulation limiting our ability to test for differences. We were able to test for differences using 4 lakes that were changed to an over/under regulation, and 4 lakes that were changed to a length and bag limit regulation. Both regulation types had a decline in total CPUE and CPUE of crappie over 10-inches from before until after the regulation was implemented (Figure 102.6). The decline in total crappie CPUE in lakes changing to over/under was marginally significant (t = 2.72, P = 0.07). CPUE of fish also declined in the 8 to 10 inch range where harvest was newly allowed, yet this difference was not significant (t = 2.12; P = 0.12). These changes were expected as the regulation was relaxed in order to allow limited harvest on fish 8-10 inches as well as harvest on larger fish 10 inches and above. However the increased harvest resulted in a reduced CPUE of crappie especially those larger than 10-inches which may not be the desired result. We will expand the database in future segments to include more lakes as they are sampled in order to further evaluate catch rates and size structure of black and white crappie as a result of new regulations.

Recommendations:

Several regulation types are currently in effect for crappie in Illinois, but little is known about how successful they are at improving population abundance or size structure. It is possible that certain regulations could work better on some lakes more than others, or could serve different means (numbers versus size). The limited analysis thus far performed on changing regulations has shown some differences potentially due to changing harvest rates. In particular, allowing harvest on fish below a previously imposed 10-inch length limit was successful at reducing fish in the 8 – 10 inch size class. In lakes with an abundance of smaller fish just below a length limit, allowing harvest may reduce the number of these fish. However, we have observed some evidence that this may reduce the overall number of fish in a lake including those of larger size and caution should be used when employing this regulation. Size structure did not vary significantly among regulation types suggesting that there is no advantage to one regulation type across all systems. Further research will focus on examining different length limits and bag limits to determine what size and level of harvest may be most appropriate.

In future segments we will incorporate FAS fyke net data from IDNR sampling to better evaluate crappie catch rates. We will examine differences in size structure among regulation types to determine if there are differences in quality, preferred, and memorable crappie depending upon regulation. We will also examine differences between black and white crappie populations to determine if the species respond differently to regulations. Time series analyses are limited by their lack of a control. To address these limitations, we will examine lakes where regulations have changed using a before/after/control/impact (BACI) design and determine if regulations affect crappie populations. We will attempt to incorporate creel data when available to determine the amount of harvest and how regulation relates to catch rates. Findings will be used to make recommendations regarding different regulations and how they affect a crappie population. With this work, we hope to develop a framework for crappie regulation management that can be used to maintain and improve crappie fisheries throughout the state.

Job 102.3: Assessing the impact of tournament angling on largemouth bass populations.

Objectives: To assess the impact of tournament angling on largemouth bass populations.

Introduction:

In addition to recreational angling, a substantial competitive tournament fishery for largemouth bass has developed and has grown rapidly over the past several years. Previous work has shown high levels of mortality associated with these tournaments in other parts of the United States, but tournament procedures continue to improve. In addition to mortality, several sub lethal effects of tournament angling have been identified and can contribute to reduced growth and fitness of fish. Tournaments conducted during the spring have been shown to cause abandonment of nests when male bass are removed by anglers, resulting in reduced or no reproductive output from the nest. It is unknown if failure of nests that were influenced by tournaments can result in reduced recruitment on a whole lake scale. It is also unknown what the combined effects of tournament mortality, stress, and nest abandonment can have on a fish population and the life history traits of individual fish. These effects could vary depending upon the number and size of tournaments and what time of year tournament activity is conducted. There is a need to evaluate largemouth bass populations in lakes where spring tournaments exist as well identify how the intensity of tournament activity can influence largemouth bass populations.

The growth in the popularity of competitive angling events targeting black bass has been substantial in the United States over the last 40 years with exceptional growth occurring in the past decade (Duttweiler 1985; Schramm et al. 1991; Kwak and Henry 1995; Noble 2002). Highlighting this recent growth, about 18,000 events were estimated to occur in North America in 2000 whereas over 32,000 were estimated to occur in 2005 in the United States alone (Kerr and Kamke 2003; Schramm and Hunt 2007). Although tournament rules require the release of captured bass following the conclusion of the "weigh-in," high mortality (>50%) has been reported during tournaments within the last 10 years (Neal and Lopez-Clayton 2001; Gilliland 2002; Wilde et al. 2002), necessitating investigations into strategies to minimize mortality during these events. Mortality can be capture-related (i.e. hooking mortality) but can also be due to the collective impact of several sub-lethal stressors incurred by bass throughout the tournament process (Kwak and Henry 1995) such as the disturbances sustained during livewell confinement or the weighing procedure. In addition, the sub-lethal physiological disturbances incurred by bass that ultimately survive the tournament process can negatively impact growth (Wendelaar Bonga 1997) and fitness (Schreck et al. 2001; Ostrand et al. 2004) and increase susceptibility to disease (Pickering et al. 1989). Clearly, identifying factors that influence the sub-lethal and lethal consequences of tournaments on largemouth bass and potential avenues to mitigate these impacts is important for the sustainable use of bass fisheries.

Removal of spawning males by angling has been shown to reduce the reproductive success of an individual largemouth bass, often causing brood reduction and nest abandonment (Philipp et al. 1997; Diana et al. 2012). However, the population-level impact of reduced reproductive success of some individuals is unclear. In the spring, male largemouth bass build solitary, highly visible (depending on water clarity) saucer-shaped nests in the substrate in order to court and spawn with females (Kramer and Smith 1962; Pflieger 1966; Coble 1975). Once spawning is completed, females leave the nesting area and the male remains to provide all parental care of the developing offspring, a period that may last four or more weeks (Ridgway

1988; Cooke et al. 2002). While male bass are providing parental care for their broods, they are extremely aggressive (Ridgway 1988; Cooke et al. 2002) and, therefore, highly vulnerable to many angling tactics (Neves 1975; Kieffer et al. 1995). Even though this vulnerability has never been assessed accurately, many fisheries management agencies have invoked closed fishing periods, catch-and-release regulations, and various length and harvest limit scenarios in an effort to enhance or promote bass reproduction and recruitment (see Schramm et al. 1995). The strategy of maximizing reproductive success by protecting successful spawning bass from angling assumes that there is a positive relationship between reproductive success and recruitment, which has not been specifically determined. Also, density-dependent interactions in young-of-the-year largemouth bass may cause populations to compensate for the lost reproductive success of some individuals. Models have demonstrated the potential for tournament angling to cause a high level of mortality when tournament catch exceeds harvest (Allen et al. 2004). In previous studies, we have shown that tournament angling of nest guarding largemouth bass cause almost all individuals to abandon the nest (Diana et al. 2012). We have also demonstrated that when these individuals abandon the nest, there is a reduction in total recruitment and year-class strength in ponds (Diana et al. 2011). However, there is a need to assess in lakes the population level consequences of angling fish from the nest. Little is known about how varying tournament angling pressure can influence the life history traits of largemouth bass populations and the population implications of these effects.

Procedures:

Tournament angling for largemouth bass has been shown to cause nest abandonment for fish angled off the nest. However the population level effects of nests abandonment have not been examined. In this study we are conducting an experiment at Ridge Lake examining the effects of tournament-style angling of nesting largemouth bass in a population previously unexploited during the spawning season. Ridge Lake has a controlled creel operated by the Illinois Natural History Survey. The lake has traditionally been closed to fishing until mid-May and no tournaments have been conducted at Ridge Lake prior to the beginning of this experiment. In this segment we conducted no spring tournaments as a control year to previous segments where tournaments were conducted. Data from 2013 were combined with that from 3 tournament years (2007, 2010, and 2012) and 5 additional non tournament years (2012, 2011, 2009, 2008, and 2006) on Ridge Lake. Tournaments were conducted in the spring prior to the normal opening of the lake for the regular public angling season. During each tournament, anglers fished for four hours targeting largemouth bass. All fish caught were brought back to the dock, measured for total length, weighed, and scales were collected. The fish were then kept in a lakeside pen for 2 hours following the tournament when they were released back into the lake. Recruitment of largemouth bass was measured as the relative CPUE from fall electrofishing samples and mean density of young-of-year largemouth bass collected in seines in late August and early September. Additionally, a complete creel census has been conducted on Ridge Lake during the open angling season of each year. Prey resources were also monitored at Ridge Lake throughout the season (zooplankton, larval fish, seine, benthos cores, and water quality; see Job 103.1 for detailed methods). We will continue to monitor largemouth bass populations and prey resources in Ridge Lake through both tournament and non-tournament years and examine the relationship between spring angling tournaments and lake wide recruitment. No tournaments were conducted in 2006, 2008, 2009, 2011, 2012, and 2014 and these years will be used as a comparison with the years where tournaments were conducted.

We also continued to evaluate how varying tournament pressure is related to the population abundance and size structure of largemouth bass populations throughout Illinois. We identified sixteen lakes where we could obtain information on largemouth bass tournaments. In this segment, electrofishing transects were performed in each lake in the spring of 2014 and the data were combined with data collected on lakes from the spring of 2009 – 2013. On each sampling date, largemouth bass were collected, measured for total length and weighed. Scales were collected from each largemouth bass and were aged by two independent readers to determine mean length at age for fish in each lake. In spring electrofishing samples, sex was determined when possible as well as maturity status (mature or immature) and spawning status (ripe, running, or spent). Largemouth bass were collected from each lake for size ranges that were too small to determine sex and maturity status in the field and returned to the laboratory. Catch per unit effort was calculated for largemouth bass of all sizes, young-of-year (< 200 mm), larger than 14 inches (> 355 mm), or memorable (> 509 mm or 20 inches). Tournament pressure was determined for lakes by identifying all tournament activity on a lake. In this segment, results from largemouth bass tournaments were obtained for 2013 and discussions were conducted to arrange for data collection in 2014. We coordinated with DNR biologists, lake managers and tournament organizers to obtain records of all tournaments conducted on a number of lakes. We also worked with tournament organizers and lake managers to obtain tournament results and weigh-in data for all tournaments conducted. In addition we obtained past data from additional lakes and included them in the analysis, expanding our past database. Data was combined and summarized for the years of 2002 – 2013 to create mean tournament activity and demographics for each lake. When all weigh-in results were not available, we estimated them using similar tournaments from the same lake. We examined the intensity of tournament activity at each lake and evaluated the abundance and size structure of the associated largemouth bass population. Information was used to categorize lakes as high tournament pressure, low pressure, or no tournament pressure lakes. We compared fish populations and recruitment of largemouth bass among these three categories to determine how they are related to tournament pressure.

Findings:

In this segment, Ridge Lake was a control year and the lake remained closed to fishing throughout the spawning season. Spring tournaments were conducted in previous segments on Ridge Lake in 2012, 2010, and 2008. In 2012 tournaments, a total of 140 largemouth bass were angled during 196 angler hours in 10 tournaments resulting in a catch rate of 0.71 fish per angler hour. In 2010 a total of 7 tournaments were conducted for a total of 156 angler hours. The anglers caught 167 fish with a total of 1.07 fish per angler hour. In 2007, 7 tournaments were conducted and anglers caught 448 largemouth bass during 168 angler hours for a mean tournament CPUE of 2.67 fish/angler-hour. Angling pressure was similar to that observed in other Illinois lakes and should result in similar effects on largemouth bass communities. Largemouth bass were observed on the nest during these tournaments and many fish were caught off the nest, resulting in potential for brood loss. Recent population estimates at Ridge Lake averaged 311 largemouth bass suggesting a large portion of the spawning fish were captured in the three years of tournament angling and that the spring tournament angling is affecting a majority of the population. Largemouth bass recruitment was evaluated for 2007, 2010 and 2013 and was compared to non-tournament years in 2006, 2008, 2009, 2011, 2012, and 2013 (Table 102.3). In addition, fish populations and prey resources were compared in tournament and non-tournament years. Recruitment was assessed as CPUE of young-of-year largemouth bass from fall electrofishing. There was no significant difference between tournament and non-tournament years for CPUE of young-of-year largemouth bass ($F = 1.01$; $P = 0.35$), CPUE of largemouth bass greater than 200 mm ($F = 0.05$; $P = 0.83$) or CPUE of bluegill ($F = 0.61$; $P = 0.47$) from fall electrofishing samples (Figure 102.7). We also observed no significant differences in prey resources in tournament and non-tournament years ($P > 0.05$ for larval fish, zooplankton, and benthic invertebrate densities). We have not observed thus far any influence of spring tournaments on largemouth bass recruitment or subsequent populations. We plan to continue to alternate years of tournament and non-tournament spring angling at Ridge Lake to continue to examine the influence of tournaments on largemouth bass populations.

Information from tournaments conducted on 12 lakes was used to evaluate population effects of varying tournament pressure. All tournament activity was recorded for each lake and tournament results were used to evaluate the tournament pressure (Table 102.4). In addition we identified 4 lakes where no largemouth bass tournaments occur and used these lakes as a control to compare largemouth bass populations across varying tournament pressure. Tournament pressure was calculated as angler hours per acre and varied from 0 to 7.3 hours/acre. The mean number of tournaments held on a lake was 22.1 and ranged from 0 to 58.1 tournaments. We also calculated the mean tournament demographics including the size and length of tournaments, size of fish caught, catch rates, and angler success (Table 102.5). The mean number of participants across tournament lakes was 36.4 anglers and the average tournament was 6.6 hours long. On average, tournaments weighed in 41.9 fish and anglers caught from 0.07 to 0.25 fish per hour. When examining only the lakes with tournaments, lake size was significantly correlated with the number of anglers per tournament ($r = 0.62$; $P = 0.02$). Larger lakes tended to have larger tournaments with a higher number of participants. Despite having larger tournaments, the size of the lake was not significantly correlated with total tournament pressure on a per area basis (angler hours per acre; $r = -0.02$; $P = 0.94$). Catch rate measured as fish caught per angler was only marginally correlated with tournament pressure ($r = 0.60$; $P = 0.09$). No relationships existed between catch rate and the number of tournaments and number of anglers in a tournament ($P > 0.05$). The mean weight of fish caught was marginally negatively related to the number of anglers in a tournament ($r = -0.59$; $P = 0.10$), but did not vary with any measure of catch rate or tournament pressure ($P > 0.05$). Anglers may be competing for the same pool of fish and fishing spots results in having to weigh in smaller fish.

Catch per unit effort was calculated from spring electrofishing transects for all largemouth, young-of-year, largemouth bass over 14 inches, and memorable fish in each lake. The CPUE of memorable sized fish was the only fish population variable that was significantly correlated to any measure of tournament pressure and was negatively correlated with the number of fish caught in tournaments ($r = -0.69$; $P = 0.04$), but not total angler hours per acre ($r = 0.20$; $P = 0.52$) or any other measure of tournament pressure. When lakes were separated into categories of tournament pressure, CPUE was not significantly different for total CPUE ($F = 0.53$; $P = 0.60$), young-of-year ($F = 1.58$; $P = 0.25$), over 14-inches ($F = 2.69$; $P = 0.12$), or memorable ($F = 1.45$; $P = 0.28$) sized largemouth bass (Figure 102.8). We did not detect any changes in abundance or size structure of largemouth bass vulnerable to tournament angling or production of young-of-year fish related to tournament pressure. Lakes with no tournaments had the greatest number of young-of-year largemouth bass and had fewer fish larger than 14 inches. It is difficult to determine if these lakes have greater recruitment or if tournaments are conducted on lakes with a greater abundance of large sized largemouth bass. However, these data are preliminary based on 5 years of data. We will continue to collect tournament and largemouth bass population data on these lakes and add additional lakes to this analysis as part of future segments to further understand the influence of tournaments on largemouth bass populations.

Recommendations:

We will continue to evaluate largemouth bass tournaments and their procedures and assess how they affect fish populations. Results from the experiment at Ridge Lake have not shown any evidence of reduction in recruitment of young-of-year largemouth bass due to springtime tournaments or changes in adult populations. To assess the effects of angling practices and tournaments on largemouth bass reproduction and recruitment we will continue these experiments as part of future segments. Experimental angling tournaments were conducted on Ridge Lake in 2007, 2010, and 2013 providing assessment of 3 years of largemouth bass recruitment in years with tournament angling to compare to 5 years of non-tournament angling. We will conduct an additional tournament in the spring of 2015 and combined with previous data to fully replicate the tournament treatments. We will analyze tournament data and compare recruitment and lake characteristics with data from control years with no tournament activity to make final recommendations.

There is potential for angling to have a large influence on sportfish populations. In particular, the magnitude and frequency of largemouth bass angling tournaments have the potential to impact fish populations. This study has begun investigating the influence of tournament activity and how it varies throughout the year. We quantified tournament pressure for a number of lakes and did not observe any relationships between tournament pressure and catch rate of young of year or total largemouth bass. We did not observe any negative relationships between abundance of any size of largemouth and any measure of tournament pressure or angler catch rate. Thus far we have no evidence of tournaments negatively affecting largemouth bass populations. In future segments, we will incorporate FAS data from DNR biologist electrofishing sampling to supplement INHS electrofishing data. We will continue to determine sex and ages of largemouth bass in lakes with varying fishing exploitation. We will examine how angling activities influence sex specific characteristics such as growth, longevity, and age of maturity. Using these data, we will be able to make predictions about how angling will affect recruitment of largemouth bass and adult populations allowing us to identify the potential impacts of tournaments and harvest to life history characteristics in largemouth bass populations. We will continue to expand the number of lakes and tournaments we gather information from as we develop more working relationships with lake managers and tournament directors. The more lakes incorporated into these analyses, the better we will be able to determine if tournament angling has any measurable effect on largemouth bass populations on a lake wide scale. Ultimately managers may be able to regulate tournament activity based on these data and reduce the impact of tournament angling on largemouth bass populations.

Study 103: Habitat Restoration

Job 103.1: Evaluation of habitat manipulations on largemouth bass recruitment in Illinois lakes.

Objectives: To determine the influence of vegetation on largemouth bass recruitment and evaluate vegetation management techniques.

Introduction:

Aquatic vegetation is a habitat feature that influences the abiotic and biotic conditions that determine largemouth bass recruitment strength. Aquatic vegetation is often an important habitat feature for age-0 fishes and recruitment (Wright 1990; McRae and Diana 2005). Aquatic vegetation can benefit fish by decreasing turbidity, providing substrate for spawning, increasing structure for avoiding predators, and acting as habitat for important prey (Savino and Stein 1982; Carpenter and Lodge 1986; Scheffer et al. 1993). Previous examinations of the effects of aquatic vegetation on largemouth bass growth and recruitment have been mixed. Whether or not aquatic vegetation has a positive or negative effect on YOY largemouth bass is likely to be dependent on the level of vegetation coverage. Too much vegetation will negatively influence YOY largemouth bass foraging efficiency and subsequent growth (Anderson 1984; Caliteux et al. 1996; Sammons et al. 2003), while a moderate amount of coverage could positively affect YOY survival (Miranda and Pugh 1997). Any benefits provided will also vary by the type of structure offered by different vegetation species (Havens et al. 2005). In this job, we are evaluating the role of vegetation by relating densities and types with largemouth bass recruitment. In addition we are evaluating vegetation management techniques by measuring changes in fish populations before and after vegetation is manipulated.

Procedures:

We continued a multiple lake experiment to evaluate different vegetation management strategies. In this segment, we continued field sampling of the 11 lakes including six for control conditions, three for rehabilitation conditions and two for vegetation removal. Largemouth bass populations, vegetation, prey resources, and fish communities were monitored. Three electrofishing transects were sampled on two dates in the spring and two in the fall at each lake. All fish were identified to species and measured for total length. Largemouth bass were also weighed and scales were taken for age and growth estimation. Benthic invertebrates were sampled two times annually in June and August at six sites using a stovepipe sampler. Zooplankton, larval fish and seine samples were performed bimonthly on 8 lakes and monthly on the remaining 3 lakes. Larval fish were collected using a 0.5 m diameter plankton push net with a 500um mesh and a 1:5 width to length ratio. Larval pushes were sampled for 5 minutes and total water sampled was measured using a torpedo flow meter mounted in the center of the net. Zooplankton was sampled using vertical tows at 4 inshore and 4 offshore locations at each lake using 0.5 m diameter plankton net with 63 um mesh and a 1:3 width to length ratio. All samples were preserved and brought to the laboratory where they were identified and counted. Seine samples were taken at 4 shoreline locations on each lake using a 1.2 x 9.1 m seine with a 1.2 x 1.2 m bag. The width, length, and depth of each transect were recorded to determine the volume of water seined. All fish collected were identified to species and a minimum of 50 individuals were measured for total length and additional fish were counted.

Lakes were mapped for vegetation in June and August using GPS mapping techniques. In this segment, GPS was used to trace the vegetated edge and waypoints to identify transitions in types and densities of vegetated areas. GPS data was then converted into GIS layers and digitized in ArcGIS 9.1. Once areas of homogenous vegetation were identified, density and mass of each species was measured. Ten rings of 0.5 m diameter were distributed throughout the different vegetated areas. All vegetation in a ring was removed (excluding the root mass), separated and identified to species and weighed. The mass of each vegetation type in a ring was used as a representative sample for the vegetated area. These rings will be used to estimate densities and biomass of each vegetation type present. GIS tools were then used to calculate vegetated area and vegetated perimeter of the lake. Vegetation rings were used to assign densities and mass of each vegetation type to polygons of homogenous vegetation.

In addition, we began to develop side scan sonar techniques for mapping vegetation to increase the accuracy of vegetation coverage measurements. We conducted intensive vegetation sampling at monthly intervals to quantify vegetation using our traditional GPS technique as well as using side scan sonar mapping techniques. We compared these techniques to determine if side scan sonar could be effectively utilized to map vegetation and develop standardized methods. In this segment, we began using the side scan mapping to supplement GPS vegetation mapping on all 11 lakes in this project. A side scan sonar transducer was mounted to the bow of the boat and transects were run along the shoreline of each lake. In addition we ran transects through the open water area to detect submerged vegetation and to map as much of the lake bottom as possible. If a lake was too large to map completely, we performed transects at 8 locations in each lake (4 cove, 4 main lake). We performed side scan sonar sampling at the same time as we mapped with traditional methods in order to determine the species and density of the vegetation present. This information was then extrapolated to the sonar images based on texture and color of the image representing each vegetation type. We will examine potential GIS image analysis methods to aid in automating a classification system that can be used on large side scan files allowing managers to map large areas of lake bottom quickly and evaluate vegetation coverage as well as substrate type and abundance of woody habitat.

Management to increase vegetation has continued on Dolan Lake, Lake Paradise, and Woods Lake. Dolan Lake was drawn down in winter of 2006-2007 and treated with rotenone in an attempt to remove carp and gizzard shad and expose the seed bank to promote vegetation growth. Successful reduction or removal of carp coupled with establishing new vegetated areas should increase overall vegetated cover in Dolan Lake. In this segment, we also continued to evaluate a large vegetation planting effort in Lake Paradise through cooperation with Illinois District Biologist Mike Mounce and the City of Mattoon Water Department. Lake Paradise was planted with 5 different types of submerged vegetation that were protected by cages of various sizes designed to exclude turtles and common carp beginning in 2008. Exclosures were constructed using varying lengths of PVC coated wire fencing. Fencing was shaped into a cylinder and closed using cable ties. Lengths of rebar were driven into the substrate and attached to the fencing cylinders using heavy duty wire ties to secure the exclosure in place. After attachment to the rebar, the cage was driven into the substrate an additional 50 to 100 mm (depending upon substrate) to seat the exclosure and ensure no fish passage under the fencing. Cages were planted with wild celery, sago pondweed, American pondweed, chara, and coontail. Two sizes of cages were planted, large exclosures constructed of 6.1 m of fencing creating an exclosure with a 2.0 m diameter (area = 3.0 m^2) and small exclosures constructed from 3.0 m of fencing creating an exclosure with a 1.0 m diameter (area = 0.7 m^2 approximately ¼ the size of large exclosures). Small cages were constructed in clusters of 4 or dispersed. For all treatments, planting location was along low sloping shoreline, with adequate sunlight, and shorelines protected from southern wind in order to promote successful establishment and growth of aquatic vegetation. Exclosures were sampled in summer 2008-2011 to evaluate planting success, fish abundance, and macroinvertebrate density and results were presented in previous studies. In this segment we mapped vegetation and collected data on prey densities and fish populations to evaluate changes throughout the experimental planting treatment. Woods Lake was drawn down in 2012 and after the fishery was opened to total harvest and rotenone treatment was applied in order to remove common carp and gizzard shad and expose seed banks. Woods Lake remained drawn down in 2012 through 2014 and no sampling was conducted in this segment. We aided district biologist Mike Mounce in acquiring brood stock for repopulating the fish community of Woods Lake from nearby lake populations. Largemouth bass, redear sunfish and bluegill adult breeding pairs were stocked in the lake to produce young. The lake remains closed to fishing and will remain closed until fish populations are reestablished. The lake will be allowed to refill in late 2014 and post-manipulation sampling will begin in future segments.

We have been monitoring two lakes as part of the vegetation removal treatment. Stillwater Lake and Airport Lake have high vegetation densities and are in need of treatment to remove vegetation. Monitoring of pre vegetation management began in previous segments and continued in this segment. Treatment for vegetation began in the spring of 2010. Sonar was applied to Stillwater with the intention of completely removing Eurasian milfoil from the lake as well as other vegetation which has become overabundant. Eurasian milfoil is the dominant vegetation type and is invasive in Illinois. Airport Lake was treated in 2010 with Reward two times, once in the spring and once in July. Reward is being applied to reduce the vegetation lake wide and was targeted to remove Eurasian milfoil which had begun to establish in the lake. Airport Lake has been spot treated for vegetation in the spring annually since 2010 in order to keep key areas of the lake open from vegetation. We will monitor changes in largemouth bass populations and prey organisms throughout and following the treatment period. Control lakes will be used to compare changes in largemouth bass populations to lakes where vegetation is being manipulated to determine the effects of vegetation management. Control lakes include 3 levels of vegetation (high, medium, and low) based on percent cover.

Findings:

In this segment, we continued to monitor 11 lakes to examine the role of vegetation in determining largemouth bass recruitment. Vegetative cover ranged from 0-100% in the study lakes (Table 103.1). Lake vegetation has varied among lakes across years, but control lakes with no vegetation manipulations maintained their relative vegetation coverage. Percent of the lake area that was vegetated was not significantly correlated with the perimeter of the shore that is vegetated in June ($r = 0.52$; $P = 0.12$) or August ($r = 0.25$; $P = 0.49$). Percent vegetated area was not significantly correlated from June to August ($r = 0.52$; $P = 0.12$), but percent vegetated perimeter was significantly correlated from June to August ($r = 0.81$; $P = 0.005$). The perimeter of the shoreline that is vegetated did not change seasonally, but the total vegetated area did suggesting that the amount of vegetation growth in a lake varied across seasons.

The percent of the lake that was vegetated in the fall of 2013 were significantly correlated with fall 2013 electrofishing CPUE of adult largemouth bass ($r = 0.72$; $P = 0.02$) as well as total largemouth bass CPUE ($r = 0.67$; $P = 0.03$). The fall abundance of adult largemouth bass was significantly correlated to CPUE of adult largemouth bass the following spring ($r = 0.73$; $P = 0.01$). The resulting recruitment of young-of-year largemouth bass in 2014 was directly related to the abundance of adults in a lake ($r = 0.65$; $P = 0.03$). In addition, the young-of-year largemouth bass CPUE was significantly correlated to the percent of the lake that is vegetated the previous fall ($r = 0.73$; $P = 0.02$). There is some evidence that the amount of vegetation that establishes in a lake by fall is related to both abundance of adult largemouth bass as well as largemouth bass recruitment the following year. Although this trend was observed in 2013-2014, it has not been consistent in previous years. We will continue to evaluate this relationship to determine the importance of vegetative habitat to largemouth bass recruitment. Despite significant trends between largemouth bass populations and vegetation, electrofishing CPUE for other fish species was not related to any measurement of vegetative cover in a lake. Mean annual larval fish densities were negatively correlated with the percent of the shoreline that is vegetated in both June ($r = -0.84$; $P = 0.002$) and August ($r = -0.72$: $P = 0.02$) likely due to larval fish taking refuge in the vegetation where they are not vulnerable to the larval fish nets. Vegetation could be an important habitat for these larval fish resulting in increased recruitment of prey for largemouth bass and other predators.

In order to evaluate differences in largemouth bass recruitment related to varying vegetation densities, we separated the 10 study lakes with vegetation into two categories based on the proportion of the lake area and perimeter that was vegetated. The categories were low (n=4; 0-80% shoreline vegetated), and high (n = 6; >90% shoreline vegetated). We performed an ANOVA to determine if there as a significant difference in YOY and adult (>200 mm) largemouth bass CPUE from fall electrofishing among groups. There were no significant differences in CPUE among vegetation groups for YOY ($F = 0.78$; $P = 0.40$) or adult ($F = 0.65$; $P = 0.44$) largemouth bass in 2013. We will continue to monitor vegetation densities, largemouth bass populations, fish assemblages, prey resources and lake characteristics in control and vegetation treatment lakes.

In this segment, side scan sonar vegetation assessments were completed monthly at Ridge Lake in 2013 and 2014. We expanded the side scan sonar sampling to include all 11 vegetation study lakes in 2014 and each lake was sampled in June concurrently with the GPS mapping. Preliminary analyses of the images from Ridge Lake have demonstrated that vegetation is clearly distinguishable in side scan images and can be digitized to determine % cover and % shoreline vegetated. In addition, the visual assessments of vegetation are underestimating total vegetation cover that are clearly shown in the side scan images. In particular, vegetation extended further offshore than was mapped by field crews using visual assessment and areas of offshore vegetation persisted in Ridge Lake that were not detected visually (Figure 103.1). In addition substrate and woody habitat were easily discernable from these images and will be quantified using these methods. We will analyze images from 2014 sampling and quantify vegetation using both methods to make comparisons. We hope that better estimates of vegetation will result in a better understanding of sportfish population dynamics. We plan to develop a method that managers can use to assess vegetation and habitat in lakes they are managing with limited effort allowing them to assess vegetation when making management decisions and identify areas of habitat restoration needs.

In this segment, we evaluated the rehabilitation effort at Dolan Lake by examining the catch rates of gizzard shad and common carp, the fish targeted in rotenone treatments. CPUE of gizzard shad from electrofishing dropped from a mean of 14.2 fish/hour in 2001 – 2005 prior to the rehabilitation, to 2.1 fish/hour in 2007 – 2010 (Table 103.2). Despite this initial drop, the catch rates of gizzard shad increased to 27.3 fish/hour in 2011, were the highest we have observed in Dolan in 2012 at 108.3 fish/hour and remained higher than the pretreatment mean in 2013 (26.0 fish/hour). The gizzard shad population has rebounded in Dolan Lake to higher levels than before the drawdown and rotenone treatment. CPUE for common carp in Dolan Lake dropped from a mean of 1.2 fish/hour in 2001-2005 to no carp being sampled from 2007 -2013. The drawdown and rotenone has successfully reduced the number of carp in the lake to a level that we have been unable to detect them in electrofishing or larval fish samples. Decreases in gizzard shad and carp densities should allow water quality changes and reduce feeding and uprooting of vegetation allowing the density of plants to increase.

Before the drawdown and rotenone treatment, Dolan had a mean of 1.7% of the surface area and 6.5% of the perimeter vegetated in the fall from 2002 through 2005. In 2007 following the treatment, 78% of Lake Dolan's shoreline contained vegetation. Vegetated shoreline increased to a mean of 84% and vegetated area increased to 21% in the years following the treatment (2007-2013). Concurrent with the increase in vegetation, CPUE of largemouth bass also increased following the treatment. Mean CPUE of YOY largemouth bass increased initially from 7.4 fish/hour (2001 – 2005) to 25.7 fish per hour (2007-2008), but dropped off to similar leaves after the first few years following treatment to 7.0 fish per hour (2009 – 2013). Adult largemouth bass population have however increased following treatment from 7.6 fish/hour to 44.3 fish/hour and has remained high throughout 2007 - 2013. It appears that the rehabilitation efforts at Dolan Lake have resulted in an increase in vegetation and an increase in the number of YOY and adult largemouth bass. We will continue to monitor Dolan Lake as the lake has been opened again to angling to determine if the largemouth bass population can sustain higher numbers.

In spring of 2013, both Airport Lake was spot treated chemically to remove vegetation from areas to allow fisherman access. The treatment in Airport Lake in 2013 occurred shortly following our spring vegetation assessment. In 2012 and 2013 we observed some decrease in vegetation area with only 20% area vegetated in the fall of 2012 and 15% in the fall of 2013. The shoreline of the lake has remained entirely vegetated throughout the treatment period and decrease in vegetation is primarily a result of cropping the vegetation down from the surface and the lake is still heavily vegetated. In all previous years fall assessments of vegetation (2007 – 2011) showed 100% vegetative cover at Airport Lake despite treatment (Table 103.3). CPUE of YOY fish has decreased since treatments were initiated in 2010 from a mean of 38.7 fish/hour in 2007 – 2009 to 8.0 fish/hour in 2010 – 2013. Adult populations have fluctuated, but have not changed over the course of the treatment. Airport was treated again in the spring of 2014 and we will report findings in future segments.

Stillwater Lake was treated in 2012 following our spring vegetation assessment. The coverage of vegetation in Stillwater Lake was very high in the years prior to treatment (100% cover and 100% perimeter 2007 – 2009). Once chemical treatment began in 2010, the portion of the lake that was vegetated decreased significantly (Table 103.3). Although the shoreline became vegetated by 2011, the lake retained open water area and the lake was not 100% covered with vegetation. Largemouth bass abundance has not changed thus far over the course of the treatment. Mean CPUE of YOY largemouth bass was 20.6 fish/hour before the treatment and remained high for 2 years following the initial treatment. The number of YOY largemouth bass observed has dropped to low levels in 2012 and 2013 with a mean CPUE of only 1.8 fish/hr. Mean adult CPUE was 11.3 fish/hour prior to treatment and was similar at 13.2 fish per hour following treatment. The lack of change in the largemouth bass population suggests that you can treat a lake to remove vegetation for recreational purposes without negatively influencing largemouth bass populations. However we have begun to see decreases in young-of-year numbers in both Airport and Stillwater Lakes. The reduced recruitment may lead to decreases in the number of adult largemouth bass if recruitment remains low. We will continue to follow these lakes to determine if recruitment is being limited through the treatment of vegetation. Stillwater Lake is closed to fishing, so we cannot predict how the population would react with angling mortality. We will continue to follow vegetation changes in these two lakes and evaluate changes in largemouth bass recruitment through spring and fall sampling.

We have performed major vegetation planting efforts at Lake Paradise, but had little success in increasing lake wide vegetation. There is some plant survival in the predator exclosures, but there is little evidence of the vegetation expanding outside of the protective barriers. New plant colonies may be able to establish in other parts of the lake from the parent colonies we have planted, but there is little evidence at this time. Percent vegetated lake area and shoreline has remained constant (% Area pre = 13; post = 6; % Shoreline pre = 51; post = 45). Largemouth bass catch rates have remained constant throughout the treatment period and have shown no increase due to planting efforts (Table 103.3). We will continue to monitor Lake Paradise to document if the established plant colonies spread to other parts of the lake and if so how it influences the largemouth bass population.

Recommendations:

Additional information on the role of aquatic vegetation to largemouth bass recruitment has been identified as an important goal for management in Illinois. There are a number of potential management strategies for manipulating vegetation that are of interest to managers in Illinois, including chemical treatment to reduce overabundant vegetation and/or nuisance vegetation (e.g. Eurasian milfoil) and habitat restoration to increase vegetation where it is lacking. We have continued a multi lake experiment examining lakes with a range of vegetation densities and have been measuring recruitment of largemouth bass in those systems. We have continued to treat vegetation in Stillwater and Airport Lakes and will continue to monitor changes of vegetation for several years. Vegetation removal in these lakes has been accomplished primarily through chemical treatments appropriate to reduce the dominant problem vegetation. Although we have experienced difficulty reducing vegetation in Airport Lake, we have successfully reduced lake wide vegetation cover in Stillwater without negatively affecting the largemouth bass population. One concern of chemically treating vegetation is that it will result in reduced water quality resulting in decreasing fish populations. We have observed the CPUE of young-of-year largemouth bass to decrease in 2012-2013 in both lakes which may be indications of reduced populations, but the adult CPUE has remained constant throughout the vegetation treatments. In future segments we will further examine how water quality has changed in these lakes to determine if the vegetation treatment has any effects on the nutrient loading and the food web in each lake. We will further evaluate changing water quality and prey resources to see if they have changed due to vegetation management.

We will continue to monitor the vegetation in these lakes and evaluate the success of the removal process. We will continue to monitor fish exclusion fences and transplanted vegetation at Lake Paradise and assess if increases in vegetation are observed. During the next several years, we will monitor the lake-wide implications of these vegetation enhancement efforts. In Dolan Lake, the water level was drawn down in an attempt to eliminate carp and gizzard shad. We expect through the removal of these fish and the exposing of the seed bank, that vegetation will increase in the lake. Initial measurements of carp and gizzard shad indicated the fish removal efforts had been successful at reducing their numbers. However, gizzard shad numbers have increased since the initial treatment and they have reestablished at greater numbers than prior to treatment. Vegetation at Dolan Lake has increased since the drawdown and fish removal has coincided with increases in largemouth bass populations. Largemouth bass populations were restocked in the lake and the fishery was closed to harvest for multiple years. It is unclear if the reduction of carp and increase in vegetation is the cause of the improved fishery or if the population will remain high now that harvest is allowed. We will continue to monitor the largemouth bass population in Dolan Lake to evaluate the success of the rehabilitation.

Implementation of side scan sonar techniques for quantifying vegetation has reduced the amount of time required to conduct vegetation sampling as well as increased the accuracy of measuring submerged vegetation. In future segments, we will continue to develop these methods and use them to better assess the importance of vegetation to sportfish communities. We will continue to monitor control and treatment lakes and relate changes in largemouth bass recruitment, growth, and abundance to management practices. Largemouth bass densities in the fall were related to the amount of vegetation in the lake. The number of largemouth bass in the fall was also directly related to spring numbers and the number of young-of-year produced, resulting in higher recruitment in vegetated lakes and lower recruitment in lakes with less vegetation. There is a need for vegetated habitat for both young-of-year and adult largemouth bass for both cover from predators and for habitat of prey. We will continue to assess vegetation cover and how it relates to largemouth bass populations to guide vegetation management on Illinois Lakes. We will evaluate largemouth bass recruitment, abundance and growth in lakes with varying vegetation densities in order to identify critical levels of vegetation to target for management.

Job 103.2: Habitat value in mid-sized rivers in Illinois.

Objectives: To develop standard sampling techniques and evaluate the influence of habitat on sportfish in mid-size rivers.

Introduction:

Habitat restoration is also commonly employed in rivers and streams and Illinois is interested in developing a plan for habitat restoration in mid-sized rivers. The IDNR current sampling procedures make relating sportfish populations to habitat structure difficult. Sportfish and habitat sampling procedures must be developed that allow direct comparison of the two, aiding in the identification of restoration needs and methods for evaluating restoration techniques.

Local habitat conditions have traditionally been used to explain fish populations in smaller streams and rivers (Wiley et al. 1997; Diana et al. 2006; Shea and Peterson 2007; Rowe et al. 2009; Neebling and Quist 2010). Temperature, substrate, available cover, velocity, vegetation, competition and predation, channel morphology, and flow have all been related to fish presence and reproduction (Gordan and MacCrimmon 1982; Fausch et al. 1988; Pusey et al. 2000; Diana et al. 2006; Remshardt and Fisher 2009). The scale which habitat is assessed can influence the observed relationship with fish and restoration and conservation objectives (Lewis et al. 1996; Dauwalter et al. 2007; Bouchard and Boisclair 2008; Schwartz and Herricks 2008; Le Pichon et al. 2009; Flotemersch et al 2011). It is important to limit the scale of assessment by breaking habitats into small enough segments to relate to fish use (Schwartz and Herricks 2008; Flotemersch et al 2011) as well as include large enough areas to consider all habitats available (Dauwalter and Fisher 2008). Both site scale habitat and landscape scale habitat variables have been shown to influence fish densities and distribution and both should be considered (Creque et al. 2005). In order to relate habitat to sportfish communities, it is important to consider the size of the habitat unit and examine multiple spatial scales.

Many factors can influence sportfish communities observed in stream and river systems. Fish movements in river systems can be large allowing them to utilize different habitats (Bunt and Cooke 2001; Lyons and Kanehl 2002). Habitat use of fish can shift depending upon the time of year due to food availability, reproduction, and refuge (Schlosser 1991; Schlosser 1995; Lyons and Kanehl 2002; Dauwalter and Fisher 2008; Paukert and Makinster 2009). Connectivity to lentic systems can also be important as fish can move between systems yet there may be distinct separate populations of river and lake oriented fish based on habitat preference and reproductive traits (Barthel et al. 2008). Fish can also alter the habitat (e.g. prey availability) if it is dynamically affected by density and prey availability can depend on past and present fish communities (Hayes et al. 1996). All of these factors must be considered when attempting to relate fish to habitat.

The river continuum concept suggests habitat shifts for fish as one moves from headwaters to the mouth of streams resulting in varying biotic and abiotic factors (Vannote et al. 1980). Species distribution is closely related to position along the up-stream to downstream gradient primarily due to habitat shifts (Buisson et al. 2008; Johnson et al. 2009; Paukert and Makinster 2009). While large rivers and small streams have been heavily studied, less attention is given to mid-sized rivers and their habitat and fish communities (Lyons et al. 2001; Neebling and Quist 2010). Fish communities and their utilization of habitats could vary greatly compared to those observed in larger or smaller systems. Most work that has been done with sportfish and river habitat has focused on smallmouth bass (Walters and Wilson 1996; Dauwalter et al. 2007; Barthel et al. 2008; Dauwalter and Fisher 2008; Johnson et al. 2009; Remshardt and Fisher 2009) with few studies on largemouth bass and other species (Freund and Hartman 2005; Wallace and Hartman 2006; Love 2011; Johnson et al. 2009) and rarely examined in mid-sized rivers. Few studies have examined how sportfish populations relate to habitat in rivers and streams other than when sportfish are lumped into community metrics or diversity assessments (except see Gutreuter 2004). There is a need to identify habitat use by sportfish and critical habitat needs and how they relate to the need for and evaluation of habitat restoration.

Mid-sized nonwadable rivers have largely been overlooked in river projects due to sampling difficulties because they are only accessible by boat, yet contain shallow expanses and blocking snags making them difficult to navigate (Flotemersch et al. 2001). The Kaskaskia River is the second largest river in Illinois, starting in agricultural drainage ditches in Champaign County, flowing 292 miles southwest where it joins the Mississippi River in Randolph County (INHS Kaskaskia River Technical Report, 1999). The slope of the upper River (upstream of Lake Shelbyville) is slight (averages 1.5 ft/mile). Below the dam at Shelbyville, the slope decreases, averaging 1.0 foot per mile. The watershed covers 10.2% of Illinois land, an area of 5,746 square miles. Agriculture dominates the watershed and comprises 82% of the total land use which is similar to the average in the state of 78% agriculture. Corn and soybean are the major crops produced, but wheat and livestock production are high as well. These reaches are characterized by the physiographic region of the Springfield Plain, a flat plain crossed by low, broad end moraines. In this project, we will develop methods to assess habitat in the Kaskaskia and similar sized river systems. We will conduct fish sampling at multiple special scales to determine how fish are associating with the available habitat types.

<u>Procedures</u>:

In this segment, we conducted habitat and fish sampling in the Kaskaskia River. Sampling was conducted in three reaches of the River including directly upstream of Lake Shelbyville (Upper Kaskaskia), downstream of the dam at Lake Shelbyville (Middle Kaskaskia) and upstream of Lake Carlyle (Lower Kaskaskia). Habitat was assessed using a transect method where a rope was stretched across the bankfull width. Ten habitat measurements were taken evenly spaced across the wetted width of the river. At each station we recorded depth, flow, dominant substrate, proportional substrate by class, presence or absence of wood, and channel location (active channel edge, thalweg etc.). In addition the bankfull width, active channel edge, and wetted width were measured using a rangefinder or metering tape. When wood was present, the length and width was measured and it was assigned a complexity score. Complexity scores ranged from 1-5 with 1 being a standalone log and 5 being a new fall with complex branching and attached leaves. Depth was measured to the nearest 10 cm with a stadia rod or in deeper areas with a weighted rope. Flow velocity (m/s) was measured at 60% of the depth at each point using a Marsh McBurney flow meter. Temperature (degrees C) and dissolved oxygen (mg/L) was measured with a YSI temperature/DO meter. Substrate was determined visually where possible or by using an Eckman grab. The substrate was classified by the dominant substrate class and was broken into percentage of total substrate into categories using a modified Wentworth scale. Substrate classes was defined as fine (<0.06 mm), sand (0.06–2 mm), gravel fine (2–16 mm), gravel coarse (16–64 mm), cobble (64–250 mm), and (boulder >250mm) (Fisher and Paukert 2008).

Habitat was also assessed on a larger reach wide scale using side scan sonar mapping. Side scan sonar transects were conducted along the thalweg moving downstream throughout the stream segment sampled using the transect method. Georeferenced side scan images were imported into GIS software and substrate transect data was overlayed onto the images. Habitat data collected from transects was used to determine how different habitats are represented in the images. Once substrate and habitat image types are determined, all images were digitized as homogeneous sections and assigned a substrate type. The total amount of each substrate and spatial measurements of fish use were used to assess the available habitat in each river section and how fish are associating with these different habitats.

Fish sampling was also conducted in each river segment. Fish sampling sites were conducted on the reach scale and by targeting homogeneous habitat type. Reach sampling was conducted similar to IDNR methods using 15 minute shoreline transects where habitat was sampled as it is encountered and catch rates and species composition is determined for the reach sampled. Targeted habitat sampling was conducted by selecting an area with homogenous habitat characteristics. Habitats were characterized by dominant substrate type, the presence/absence of wood, depth, river unit classification (run, riffle, pool) and position in the channel (thalweg, inside bend, outside bend, channel margin). We aimed to include an array of combinations of habitat types with the goal of comparing fish use across a variety of habitats. At each site, GPS waypoints were taken at the start and end of each transect to record the location of each site, as well as measure length. Sampling of the fish was completed with 240V pulsed DC electrofishing. Habitat segments were electrofished in an ambush style where the boat is moved into the habitat and the electrical current is engaged. The area was sampled until fish were no longer observed. Time and area of each sampling segment were measured to assess catch per unit effort and the size of the habitat being sampled. All fish were identified and measured to the nearest millimeter, then released. Fish and habitat data will be analyzed at multiple spatial scales to determine the most appropriate method of assessment. Sampling areas will be analyzed individually as well as pooled into reaches and river segments. Fish communities and abundance will be related to habitat types present at eachscale. We will make recommendations based on spatial scale, fish/habitat associations, and sampling methods.

<u>Findings</u>:

In this segment, we sampled the upper Kaskaskia in fall of 2013, spring of 2014 and summer of 2014 to assess seasonal changes in habitat and fish communities. In addition ,we conducted summer sampling of the middle Kaskaskia reach to compare among reaches. The lower Kaskaskia sites were sampled in July of 2014 and results will be reported in the next segment report. Side scan transects were conducted at each river segment concurrent with instream habitat and fish sampling. Side scan images were downloaded and imported into a GIS database. These images will be combined with instream habitat data and digitized in the next segment. Habitat transects were also conducted concurrently with side scan transects and will be used to delineate habitat types in the side scan images and to compare habitats found in each segment of the river. These transects are currently ongoing and therefore will be summarized and compared in the next report.

In this segment, we analyzed fish data collected associated with the microhabitat sampling to determine what fish are present in different habitat types. Thirty five sites were sampled from fall 2013 to summer 2014. A total of 38 species were collected in the 35 sites. The most abundant fish were in order, gizzard shad (Dorsoma cepedianum), largemouth bass

(Micropterus salmoides), white crappie (Pomoxis annularis), longear sunfish (Lepomis megalotis), black crappie (Pomoxis nigromaculatus), and bullhead minnow (Pimephales vigilax). A variety of habitats were sampled in the upper and middle Kaskaskia River (Table 103.4). Fish were found to be more abundant on gravel substrate, averaging 10.4 fish per minute. Silt and cobble substrates both averaged almost 7 fish per minute. The average of fish caught per minute on a cobble substrate was the lowest at 6.2 (Figure 103.2). Fish abundances were higher on sites with woody habitat than at sites without woody habitat. The CPUE with presence of wood was 8.8, whereas an absence of wood resulted in only 5.4 fish per minute. Many individual species were more abundant in sites with woody habitat present, including bluegill, largemouth bass, walleye, crappie (combined white and black), and common carp (Figure 103.3). Two species that were more abundant in the absence of wood were freshwater drum and shorthead redhorse. When considering channel position, fish were most abundant on inside bends, averaging 15.7 fish per minute. Outside bends and shoreline runs were the next most abundant channel position, both averaging around 7 fish per minute, whereas middle runs only produced 4.4 fish per minute. Total CPUE was negatively correlated with mean depth at a site ($r = 0.50$; $P = 0.007$); as fish were found at higher abundances in shallower sites (Figure 103.4). Inside bends were more shallow than the other habitat types and fish may be using these areas as refuge from flow.

Recommendations:

Habitat associations with fish abundance were apparent for substrate, presence of woody habitat, and channel position. Fish tend to be more abundant on gravel, wood, and inside bends. More significantly, crappie preferred wooded habitat, and fish are more likely to be found in shallower water. These associations could be helpful for developing management strategies of mid-sized rivers. Based on these preliminary results channelization and loss of woody habitat are two potential threats to fish in midsized rivers. First, channelization is occurring mainly to control flooding, drain wetlands, improve navigation, prevent erosion, and to increase drainage from agricultural fields. When channelization happens, many unique aquatic habitats are lost. Bends are eliminated, channels deepen, and substrate and flow are homogenized reducing the amount of shallow habitat that fish prefer. The consequences of these rapid restructuring of the morphology and river dynamics are long-lasting (Urban and Rhoads 2003). It is important for fish to have diverse habitats available so that they may select their required habitat based on life history traits. Second, removal of woody debris in rivers should be avoided. Instream removal happens to improve navigation or out of convenience, while bank removal occurs for recreation, residential, commercial, or agricultural use. We have shown that many fish species, especially crappie select wooded habitat over non wooded habitat, so it is important that managers reduce the removal of wood, or even create woody habitat for aquatic species. A manipulative experiment by Angermeier and Karr (1984) also showed the association of fish to wooded habitats. Wood was removed from one side of a stream, and fish were usually more abundant on the side with woody debris than on the other side highlighting the need for wood in rivers and streams.

We will continue to develop methods for sampling fish in mid-sized rivers that will allow for direct comparison with habitat assessments. We will determine the size of sampling units required to associate sportfish with different habitat types. Guidelines will be developed for conducting habitat sampling based on standard procedures and compared with work done outside of Illinois. We will evaluate the current sampling used by the IDNR and examine data collected as part of previous monitoring. Data has been initially collected on both habitat and fish populations in the Kaskaskia River. We will expand to additional rivers (e.g. Embarras, Fox, Kankakee) in future segments. Data will be used to determine the potential value in evaluating sportfish associations with habitat. We have compared the methods currently used to those commonly used in the literature and by other states and will make recommendations on the need for improving or adjusting the current collection methods. Habitat assessments and electrofishing sampling will continue to be conducted at varying scales to determine what level of refinement is needed to develop relationships between habitat and sportfish. We will utilize rapid habitat assessment techniques, transect habitat measurements, landscape habitat identification using GIS, and riffle/run/pool measurements to assess habitat. Electrofishing transects will be performed at short durations and habitat targeted and compared to data collected from longer electrofishing transects. Varying the assessment type and scale will allow tests of the sample requirements for relating sportfish to habitat type. We will identify important habitats for sportfish and assess the potential for habitat restoration projects by determining the availability of different habitats and identifying which may be limited. The information resulting from this study will be used to develop a standardized sampling procedure for collecting habitat and fish population data in mid-sized rivers in Illinois that can also be used in evaluating habitat restoration projects in the future.

Study 104: Recruitment of Sportfish

Job 104.1: Evaluation of the effect of spawning refuges on largemouth bass recruitment.

Objectives: To evaluate the effects of fish refuges on Illinois bass recruitment and size structure.

Introduction:

Recruitment of sportfish is one of the main factors influencing the structure of adult fish populations. Understanding the factors that influence recruitment in sportfish is paramount to managing populations and predicting future fisheries. Many fish species undergo survival bottlenecks that are caused by limitations in their environment. Managing for conditions that are beneficial to survival should enhance fish populations. While recruitment in some fish species is widely studied, it is not well understood for all species of sportfish. In particular, additional research is needed to understand what factors influence recruitment in crappie, channel catfish, and flathead catfish. Although some studies examining crappie species have been conducted, different factors have contributed to recruitment success and in general it is highly variable, making their populations difficult to manage or predict. Most studies are conducted on a limited number of systems and there is a need for a robust study including multiple lakes.

The factors influencing largemouth bass recruitment have been studied in greater detail than other species. In previous studies, we have identified that largemouth bass angling can greatly reduce the reproductive potential of fish especially if they are removed from the nest. Fish that are harvested at small sizes will also be eliminated from the spawning population. The combined effects of angling may result in reduced recruitment success for largemouth bass populations. One potential management strategy is to restrict angling in areas of the lake and provide a refuge for spawning fish where recruitment will be unaltered by angling. Refuges have been established in multiple lakes in Illinois, but there is little information on how they have influenced recruitment both inside the refuge and on a lake wide scale. There is a need for investigating the effects of refuges closed to angling and their potential to increase largemouth bass recruitment for an entire lake. We have implemented angling refuges on two lakes in Illinois in order to examine their utility at improving largemouth bass populations through protecting nesting fish from brood loss due to removal from the nest. In addition fishing mortality will be eliminated in this part of the lake potentially leading to increased survival of adult fish.

Procedures:

We examined largemouth bass populations in two lakes before and after the implementation of fishing refuges. In this segment, we continued to assess changes in largemouth bass recruitment and abundance due to two refuges on Otter Lake. In the summer of 2010, two refuges were closed to fishing in Otter Lake by running a buoy line with no fishing signs attached. We began post-refuge sampling in Otter Lake in 2011 because the buoy lines were put in place after largemouth bass spawning was completed in 2010. Samples conducted in 2007 through 2010 were considered pre refuge conditions and samples collected from 2011 through 2014 are considered post refuge conditions.

Sampling was conducted on two dates in the spring and two dates in the fall for each year. On each sampling date, one 30 minute electrofishing transect and one seine haul were conducted in each refuge location. DC electrofishing (240V, 60Hz) was conducted on one date in the spring and one date in the fall and AC 3-phase electrofishing (240V) was conducted on an alternate date in the spring and the fall. Seines were conducted using a 9.2-m bag seine pulled along the shoreline at fixed transects. In addition, three control sites were sampled (1 electrofishing transect and 1 seine haul in each) within the lake. One reference was located near each proposed refuge, and the final reference location at the midpoint between the refuge sites. Fish were identified to species and total length was recorded. All fish were counted and up to 50 fish were measured for each species. All largemouth and smallmouth bass collected inside refuge sites were given an upper caudal fin clip in order to determine if fish in the refuge move into adjacent areas of the lake. Catch per unit effort (CPUE) was then calculated as the number of fish per hour of electrofishing and number per square meter area seined. These data will be compared to another lake where refuges were initiated, Clinton Lake. On this lake, sampling during 1999 – 2001 represents pre-refuge and 2002 to 2012 represents post-refuge.

<u>Findings</u>:

We continued to monitor refuge and reference sites in Otter Lake during this segment. In pre-refuge monitoring in the spring and fall of 2007- 2010, we observed lower catch rates of largemouth bass in the proposed refuge sites compared to the control sites (Table 104.1). The proposed refuge sites appeared to be in areas where largemouth bass were abundant and spawning was taking place, but did not have as many fish as the control sites. After the refuges were closed, electrofishing CPUE of largemouth bass in 2011 through 2014 remained lower in the refuges than the control sites (Figure 104.1). We did not observe a change in abundance of largemouth bass either in the closed refuges or in the control sites. Very few young-of-year largemouth bass were collected in either the refuge sites or the control sites following the closing of the refuges (Table 104.2). There is little evidence that closing these areas to angling has led to increased reproduction or enhanced largemouth bass populations in the first 4 years following implementation of the refuge. These results contradict what was observed at Clinton Lake where both young-of-year and adult largemouth bass were observed in greater numbers inside the closed refuge. It is not clear why the refuge in Otter Lake has not resulted in increased largemouth bass populations at this time. The refuge in Otter Lake was opened to fishing in the spring of 2014 at the request of the lake management. We will continue to follow the year class of largemouth bass that would have spawned in spring of 2014 through the spring of 2015 to evaluate their abundance.

<u>Recommendations</u>:

There are many potential harvest regulation strategies that can be used to manage bass populations, including size and creel limits, closed seasons, and spawning refuges. Thus far we have been evaluating a spawning/fishing refuge on Clinton and Otter Lakes. Largemouth bass populations inside the refuges at Clinton Lake had large increases in the number of adult fish after they were closed to fishing. However largemouth bass populations outside of the refuge did not increase and there is no evidence of fish leaving the refuge and moving into the main lake. The refuge on Clinton Lake has resulted in enhanced recruitment and survival of largemouth bass, but may not increase catch rates lake wide for anglers. At this time we have not observed any changes in the largemouth bass population in Otter Lake as a result of the refuges. Neither the number of fish inside the refuges or the throughout the lake have increased. Refuges have the potential to increase largemouth bass recruitment and the abundance of adult largemouth bass inside of an area closed to angling. We did not observe any changes in lake wide bass populations at either lake. The utility of closed fishing refuges may be limited to lakes with high angling pressure where recruitment may be impacted by angling. The effects of the refuge may be limited to the area closed to fishing which does not directly benefit anglers. We will continue to follow the largemouth bass population in Otter Lake to determine if the refuges will result in better largemouth bass populations and continue to make recommendations to managers regarding the use of refuges in management.

Job 104.2: Assessment of the importance of spillway escapement in determining the survival of stocked muskellunge.

Objectives: To quantify the level of escapement in Illinois reservoirs and determine what factors influence escapement.

Introduction:

Escapement of sportfish from reservoirs decreases abundance and poses a threat to downstream systems. The factors influencing the magnitude of muskellunge escapement are not known. Previous studies of dam escapement focused on abundant species of reservoir fish. Lewis et al. (1968) found that 31% of largemouth bass stocked into a new impoundment escaped within the year. In a two year period 10,000 fish were estimated to have escaped from a 65 ha lake in Illinois (Louder 1958). Losses of fish over spillways have been shown to be species-specific in a given lake, but patterns between lakes have not been consistent (Lewis et al.1968; Paller et al. 2006). Size-specific losses have also been identified, and often adults of the population are more vulnerable to escapement (Navarro 1993; Lewis et al 1968; Paller et al. 2006). There is limited information on escapement of low-density top-predators such as muskellunge, despite anecdotal evidence and preliminary data suggesting escapement of the species is widespread. At this point we do not have a clear understanding of the mechanisms and magnitude of muskellunge spillway escapement that would be integral to developing and implementing mitigation efforts and making management decisions. Important data must be collected on the conditions (season, flow, diel period, temperature, and spillway design) associated with escapement, the traits of fish (sex, size, maturity) that are the most susceptible to escapement, and how reservoir characteristics and spillway design influence escapement. Estimates of the proportion of a population that are lost annually from reservoirs are also of great management importance and these figures will aide in making management decisions and justifying specific remedial actions.

Emigration of fish out of managed systems can influence recruitment of sportfish. One potentially major source of emigration is through dam escapement. Losses of fish over spillways are highly variable, unpredictable, and a concern to fish managers (Axon and Whitehurst 1985; Paller et al. 2006; Wahl 1999; Hergenrader and Bliss 1971). In western North America both upstream and downstream dam passage of salmonids is universally considered to be positive (Connor et al. 2000), and is often accommodated for (Raymond 1988; Champman et al. 1997). But in the Midwest "dam escapement", the permanent emigration of fish past the impounding barrier of a reservoir, is a major detractor from the goal of establishing and maintaining abundant sportfish populations (Louder 1958; Wahl 1999). Factors thought to contribute to dam escapement of sport fishes include movement related to spawning or foraging, spillway design, habitat preference, and amount of overflow (Louder 1958; Lewis et al. 1968; Paller et al. 2006). In many scenarios these losses are costly in consideration of the resources invested into stocking sportfish (Szendrey and Wahl 1995).

In some large tailwaters high density fisheries can be created where escaping fish are caught by anglers at high rates. Indeed, escapement has been described as essentially an annual stocking program for downstream systems (Trammell et al. 1993; Schultz et al. 2003), and when sufficient outflow creates consistent riverine conditions large bodied fishes often thrive (Harrison and Hadley 1979). But while the potential exists for productive tailwater fisheries, the influx of unwanted and often nonnative fish also carries a risk of negative effects on resident fish communities (Martinez et al. 1994; Spoelstra et al. 2008). Consequences for escapees can also be dire as habitat, prey availability, and thermal conditions in the outflow of smaller impoundments are often not adequate to support large-bodied fish.

Muskellunge are often stocked into reservoirs to create recreational fishing opportunities. Muskellunge escapement over spillways is frequently observed and reported anecdotally across the Midwest (Storck and Newman 1992; Wahl 1999). Because these fish are stocked in low numbers, have limited potential for natural reproduction in many reservoirs (Dombeck et al. 1984), and preventative barriers are often infeasible or ineffective at high flows (Plosila and White 1970), escapement could be one of the primary factors limiting development of abundant reservoir populations (Louder 1958). Preliminary examinations recorded a large percentage of a muskellunge population escaped from an Illinois reservoir and have also shown that PIT tag antennas can be effectively used to collect real-time data on escaping fish and generate estimates of escapement. To address these issues we conducted field evaluations at two Illinois reservoirs to quantify conditions under which muskellunge escapement occurs and describe the traits and proportion of muskellunge escaping from a reservoir.

Procedures:

In this segment, we continued to monitor escapement of muskellunge in two reservoirs using PIT tag arrays. Muskellunge were sampled on Lakes Sam Dale (Wayne County) and Lake Mingo (Vermillion County) in the spring of 2011 - 2103. Results presented in this report represent the completion of this job. Fish were captured each spring using fyke nets and boat electrofishing. All fish captured were measured, weighed, sexed, aged, and given a uniquely numbered RFID PIT tag. A Peterson mark-recapture population estimate was conducted with a marking period followed by a period for redistribution and then a recapture period. We used a Peterson model with the Chapman modification (Chapman 1951) to calculate population size (equation 1).

Equation 1. $\hat{N} = \frac{(M+1)(n+1)}{(m+1)} - 1$

where $\hat{N}$ is the estimated population size, M is the number of marked fish from the first sample that were returned to the population, n is the number of fish in the second sample, and m is the number of marked fish in the second sample. Based on the proportion of marked fish in the recapture sample, a binomial confidence interval for this population estimate was calculated (Seber 1982) using equation 2.

Equation 2. $\hat{N} \pm Z * SE_{\frac{m}{n}}$

where SE is standard error, m is the number of marked fish in the second sample, and n is the number of fish in the second sample.

Antennas capable of capturing PIT tag information were used to gather data on escaping muskellunge. Antennas were installed at the spillways of both lakes in order to record the number of tagged muskellunge passing over the spillway structure. Antennas were constructed from 10 gauge THHN wire fixed to high strength tech cord. The antennas span the width of each spillway (Sam Dale 16’, Mingo 46’) and cover approximately 3’ of overflow height. Concrete anchors were used to attach antennas to the spillways. Antennas were tuned and operated using

RFID interrogating and datalogging components from Oregon RFID (Portland, OR). The Lake Sam Dale antenna was powered by 2 marine 12V batteries housed in a weatherproof box along with the datalogger. The Lake Mingo antenna was powered by the main power grid using a DC converter. Each antenna was tuned for the specific inductance of that system and was checked for gaps in antennae coverage manually and was repaired as needed.

At Lake Mingo, the PIT tag antenna suffered from de-tuning in 2011 that occurred as a result of storms and severely decreased the ability of the system to detect escapement events. However, many of the muskie escaping from Lake Mingo remained in the plunge pool at the base of the dam due to the small size of the drainage exiting the lake. These fish were examined for PIT tags and were used as a conservative estimate of escapement.

Correction factors can be developed to estimate total fish passage at an antenna when detection efficiency is less than 100%. We used an outflow structure from an experimental pond facility to develop a correction factor for detection of downstream passage of fish in a spillway setting from the PIT tag antenna. Thirty six trials were conducted at each of three outflow water velocities (25, 50, and 90 cm/s, N=108 total) to simulate variability and intensity of flow that would be present in an actual spillway. For each fish passage, observations of body orientation in relation to the antennae were made and tag detection was noted. Detection efficiency was calculated as the proportion of passages resulting in a successful tag capture during these trials. A correction factor for the detection efficiency of our system was then calculated as the inverse of detection efficiency. The correction factor was then used to estimate the total number of escaping fish in the field (i.e. number of detected fish escaping x correction factor = estimated total number of fish escaping).

Data was collected on the magnitude and patterns of escapement of muskellunge from these reservoirs. Estimates of escapement for each lake were determined by total number of tags captured by each antenna in comparison to the tagged population. Demographics of escaping fish was determined by matching tag numbers to data collected from each fish at the time of sampling. Chi-square tests were used to assess differences in escapement rates between adults/juveniles and males/females. Timing of escapement were determined by time stamps made for each escaping fish carrying a tag, comparisons of escapement between daytime and nighttime were made using a chi-square test. Correlations between timing of escapement and environmental conditions including precipitation, waterlevel, turbidity, and water temperature were also made.

Findings:

The PIT tag arrays were installed in spring of 2011 at both Sam Dale and Mingo Lakes. At Lake Mingo, the PIT tag antenna suffered from de-tuning in 2011 that occurred as a result of storms and severely decreased the ability of the system to detect escapement events. However, many of the muskie escaping from Lake Mingo remained in the plunge pool at the base of the dam due to the small size of the drainage exiting the lake. These fish were examined for PIT tags and were used as a conservative estimate of escapement. Arrays were taken down in the winter of 2011-2012 and reinstalled in the spring of 2012 at both lakes. In 2012 the conditions were unusually dry and as a result there were few opportunities for muskellunge to escape from either lake. Despite the antenna being active throughout the spring and summer, there were no tag detections during this time for Lake Sam Dale or Lake Mingo. The array at Sam Dale was removed through the winter, but the array at Mingo remained in overwinter and was retuned in spring 2013.

In Lake Sam Dale, tagged fish in 2011 (N = 118) ranged in length from 415 to 964 mm and were comprised of 16 age 1, 15 age 2, 53 age 3, and 34 age 4 individuals. Mark-recapture methods estimated 186 (confidence interval 142-257) muskellunge were present in Lake Sam Dale at the time of sampling. Long-term (one year) tag retention was 100% (N = 10), similar to rates in the literature (Younk et al. 2010). In 2012, 21 fish were captured over 2, 10-day fyke net sampling periods. Of those fish no fish were recaptured within 2012 and a population estimate was therefore not possible. In Lake Mingo, tagged fish in the 2011 (N = 106) ranged in length from 337 to 1050 mm and were comprised of 7 age 1, 13 age 2, 16 age 3, 22 age 4, 17 age 5, 9 age 6, and 22 of undetermined age individuals. Mark-recapture methods estimated 189 (confidence interval 114-274) muskellunge were present in Lake Mingo. Low water levels prevented any fyke netting at Lake Mingo in 2012 and therefore no population estimate was possible. Fyke netting was conducted in spring of 2013 in Lake Mingo to supplement the number of tagged muskellunge and conduct population estimates. A total of 50 muskellunge were caught during the mark and recapture period from a total of 98 net nights (7 nets, over 7 net night mark and 7 net night recapture period). A total of 32 new tags were given during the marking period and 9 of these were recaptured. Despite the addition of new tags and the occurrence of spring flooding, no fish were observed escaping at Sam Dale or Mingo Lakes throughout the summer until the arrays were pulled in the fall. Because the only observed escapement occurred during the 2011 sampling year due to the high frequency of floods, we will focus on this field season for evaluating escapement.

In the detection efficiency experiments, 50% of fish had the axis of their body oriented at a 70-90º angle from the antenna (swimming parallel to the flow either upstream or downstream). Fish passing at this orientation had an associated 86% detection efficiency. Another 31% of fish passed the antennae at an orientation of 21-69º with an associated detection efficiency of 81%. Only 19% of fish passed with their body axis oriented at a 0-20º angle, and as anticipated based on limitations of the technology, the antenna had lower detection efficiency (71%) of these fish. Detection efficiency actually increased with velocity (72% at 25 cm/s, 82% at 50 cm/s, and 92% at 90 cm/s) which can be attributed to fish being more likely to have a body orientation that was parallel to the direction of flow as velocity increased. We estimated an 81.6% overall detection efficiency of downstream passing fish across varying water velocity. By dividing the probability of complete capture success (100%) by the detection efficiency determined in our trials (81.6%) we obtained a correction factor of 1.23.

At Lake Sam Dale, the PIT tag antenna and data logger were activated on February 22, 2011 when flow first passed over the spillway. In the spring of 2011, 24 individual tags were detected by the antennae between March 10 and May 3 (Figure 104.2). The actual number of tags detected accounts for 20.3% of the tagged population. By applying the correction factor for antenna efficiency we estimate escapement of the tagged population at 25.0% (20.3 x 1.23). By applying this rate to the estimated population size we estimate that 47 (CI 36-64) muskellunge escaped from Lake Sam Dale. In June of 2011, 27 tagged muskie were recovered below the dam at Lake Mingo (only 1 of these fish was detected by the PIT tag antenna), representing 25.4% of the tagged population of muskies in Lake Mingo. These most likely underestimate the total number due to some fish moving beyond the plunge pool. However, with this conservative estimate applied to the estimated population of Lake Mingo, we estimate that 48 (CI 29-70) muskellunge escaped from Lake Mingo during the spring of 2011.

At Lake Sam Dale, the mean length and age of escaping fish (811 ± 32 mm, 3.3 ±0.25 years) were significantly higher than those for the tagged population as a whole (744 ±26 mm, 2.9 ±0.17 years, $P = 0.03$ and 0.04 respectively, Figure 104.3). None of the tagged age-1 fish (N = 16, 400-450 mm) were detected escaping the reservoir, with disproportionately higher escapement of adults compared to juvenile fish (Chi square = 4.22, $P = 0.04$). The sex ratio of escaping fish (11F:13M) was similar to the ratio of the tagged population as a whole (53F:49M, Chi-square = 0.04, $P \geq 0.05$). At Lake Mingo, the mean length and age of escaping fish (827.3 ± 30 mm, 3.7 ± 0.28 years) was also higher than the population as a whole (804.8 ± 17 mm, 3.6 ± 0.16 years) but these differences were not significantly different. The sex ratio of escaping fish from Lake Mingo was (7F:14M) which was similar to the ratio of the tagged population as a whole (28F:39M, Chi-square = 0.9, P ≥ 0.05)

Precipitation events in the area around Lake Sam Dale typically resulted in an increase in overflow at the spillway within 24 hours but the duration of overflow varied. Duration and maximum height of overflow was variable and presumably related to rainfall intensity, duration, ground saturation, and delayed runoff from previous events. From late February to mid-May there was an almost continuous baseline flow of water over the spillway (~5 cm overflow height) between pulses from specific precipitation events. Two fish escaped on days in March that were not associated with a specific precipitation event (cumulative precipitation <0.1 cm for 3 days prior, Figure 104.2). The majority of escapement (22 of 24 fish) followed two events in early and late April that had 2 and 5.5 cm, respectively, daily rainfall at their peak. Exact peak overflow heights were difficult to determine, but these precipitation events led to >13 cm and >25 cm of overflow height, respectively.

The water level of Lake Sam Dale dropped several inches below normal pool during the summer due to evaporative processes which resulted in no summer days with spillway overflow. Precipitation throughout the fall gradually raised the water level until late November when several days of overflow occurred. A single precipitation event of > 4 cm resulted in an overflow height of >15 cm. However, during this period no tagged muskellunge escaped (Figure 104.2). As such, all muskellunge escapement detected by the antenna occurred near what has been observed as the spawning season (Parsons 1959).

A majority of fish at Lake Sam Dale escaped during daylight hours (19 of 24), with peak escapement happening in the afternoon and evening (Figure 104.4). The observed numbers of escaping fish during daylight hours was significantly higher than that expected if escapement occurred randomly throughout the diel cycle (Chi square 5.12, $P = 0.03$). Water clarity (secchi depth) values were highly correlated to precipitation (Pearson Correlation Coefficient, r = 0.34, $P < 0.01$) and temperature (r = 0.39, $P < 0.01$), whereas precipitation and temperature values were marginally correlated to one another (r = 0.20, $P = 0.06$). Because of the collinearity of these variables it is difficult to determine the influence of each variable independently. Escapement of muskellunge occurred on 11 days in the spring and no escapement was observed on 73 days. Mean secchi depth was significantly lower on days when escapement of muskellunge occurred (0.32 cm) than on days when escapement did not occur (0.44 cm, $P < 0.01$). Similarly, daily precipitation values were higher (3.9 cm for that day and 2 d prior) when escapement occurred than when escapement did not occur (1.0 cm, P < 0.01). Finally, mean daily temperature was higher on days when escapement occurred (15.8°C) than on days when escapement did not occur ($P = 0.04$, 13.1°C).

Recommendations:

Our results indicate that up to 25% of the muskellunge population in these two reservoirs can escape in a single year. However, in 2012, which was marked by drought and 2013, a dry year with some spring flooding, we detected no escapement in these same reservoirs. Therefore, it appears escapement is linked to precipitation events and daily movement behaviors of the fish. Fish were more likely to escape in the spring when large pulses in precipitation occur and are also more likely to escape in the day. The data suggest that utilization of barriers and other reservoir water regulation techniques might be effective especially during the day and around high precipitation events. However, further data is needed to determine if these patterns occur across other reservoirs and across years with different seasonal patterns. This report concludes this study and we have completed monitoring tagged muskellunge in Sam Dale and Mingo Lakes. We have demonstrated the use of a PIT tag array in observing fish escapement over a dam. The utility of the PIT tag system is the ability to determine the precise time and condition when the fish escaped from a lake resulting in management applications to reduce future escapement. Future research would result in further refinement and increased accuracy using the PIT tag antenna system as well as expand the research to additional species. Future research should focus on examining different spillway structures and flow conditions to determine the range of potential escapement and how it varies across systems. This will allow managers to determine the scale of escapement and focus efforts in areas where escapement poses the most threat to reservoir populations. Data gathered in this study will enhance the success of muskellunge stocking and help maintain populations which will improve angling in Illinois lakes stocked with muskellunge.

Job 104.3: Evaluating factors that influence crappie recruitment in Illinois lakes.

Objectives: To identify factors that influence crappie recruitment.

Introduction:

White crappie (*Pomoxis annularis*) and black crappie (*P. nigromaculatus*) are collectively two of the most sought after sportfish species in North America (Beam 1983; McDonough and Buchanan 1991; Sammons and Bettoli 1998; Boxrucker and Irwin 2002). Crappie populations are often plagued by variable, quasi-cyclical recruitment with strong year classes existing every 2-5 years (Thompson 1941; Swingle and Swingle 1967; Allen and Miranda 2001). As with most freshwater fishes, adult abundance has been linked to number of recruits (Hilborn and Walters 1992; Bunnell et al. 2006). Recent studies suggest that a combination of spawning stock characteristics and environmental variables are probably the most influential metrics for explaining and predicting recruitment variability in crappie (Dockendorf and Allen 2005; Bunnell et al. 2006).

A number of studies have identified environmental variables as being important to crappie recruitment (Jenkins 1955; Goodson 1966; Mathur et al. 1979; Bunnell et al. 2006). Factors such as water temperature, time of spawning, water level, turbidity, landscape characteristics, substratum, productivity (chlorophyll-a), zooplankton composition and abundance, and wind have been identified as being important to crappie year-class strength and early growth (Mitzner 1991; Guy and Willis 1995; DeVries 1998; Pine and Allen 2001; Sammons et al. 2001; Bunnell et al 2006; Reed and Pereira 2009). Water level has emerged as one of the most important factors to crappie recruitment in a number of studies, suggesting that water level manipulation may be a viable management practice for influencing year-class strength (Pope et al. 1996; Maceina and Stimpert 1998; Maceina 2003; St. John and Black 2004).

Recent studies have attempted to create predictive models for crappie recruitment and have been met with varying success (e.g. Bunnell et al. 2006; St. John and Black 2004). Recruitment in modeled crappie populations suggests that both population dynamics and environmental fluctuation are important in driving recruitment trends (Allen and Miranda 2001). Research that incorporates stock-recruitment models as well as environmental variables has been relatively successful at predicting crappie recruitment in lakes (Dockendorf and Allen 2005; Bunnell et al. 2006). In largemouth bass (Post et al. 1998) and crappie (Bunnell et al. 2006), models incorporating multiple life history stages have provided better insight into which developmental stages are most crucial for recruitment. Additional research is required to determine what developmental stages, spawning stock characteristics, and environmental factors are important to crappie recruitment success in Illinois. In this section we plan to evaluate crappie population metrics and relate them to environmental variables at varying spatial scales in an attempt to better understand the underlying mechanisms governing crappie recruitment.

Procedures:

In this job, we are assessing crappie populations on a set of lakes (N = 12) and determining what factors influence year-class strength. In this segment we continued our assessment of crappie populations by conducting trap netting on each lake on two dates in the spring and two in the fall starting in the spring of 2013. All fish were identified and measured for total length and weight. A subset of crappie were taken to the laboratory and scales, otoliths, and gonad scores were collected for age and growth estimates. As an initial indicator of recruitment success, larval fish were collected using a 0.5 m diameter plankton push net with 500 um mesh and a 1:5 width to length ratio. Larval pushes were conducted for 5 minutes and total water sampled was measured using a torpedo flow meter mounted in the center of the net.

We sampled lake conditions and prey resources in each lake to determine how they influence crappie recruitment. Benthic invertebrates were sampled two times annually in June and August at six sites using a stovepipe sampler. Zooplankton, larval fish and seine samples were performed twice per month on the twelve study lakes. Zooplankton were sampled using vertical tows at 4 inshore and 4 offshore locations at each lake using a 0.5 m diameter plankton net with 63 um mesh and a 1:3 width to length ratio. All samples were preserved and brought to the laboratory where they were identified and counted. Seine samples were taken at 4 shoreline locations on each lake using a 1.2 x 9.1 m seine with a 1.2 x 1.2 m bag. The width, length, and depth of each transect was recorded to determine the volume of water seined. All fish collected were identified to species and a minimum of 50 individuals per species were measured for total length, with additional fish being counted. Age-0 and older crappie abundance was estimated from spring and fall trap netting.

Findings:

In this segment we attempted to age crappie via both scale and otolith samples. We determined, as the literature suggests (Ross et al. 2005), that otoliths are far superior aging structures than scales for both species of crappie. Scales were inconsistent in their estimation of age, and acetate impressions were often times very faint or absent, causing an underestimation of age in older fish. We will use otoliths for all age and growth estimations for this job in the future.

Catch rates from trap nets in both spring and fall indicated the highest catch rates in many lakes to be age-3 fish, suggesting age-2 and smaller fish may not be fully susceptible to trap nets. It is also possible that the age-3 year class was more successful than other recent year classes, leading to their increased numbers. If this is the case, it would imply a landscape level environmental variable was affecting recruitment, however this cannot be tested until further years of sampling are conducted. Catch rates of age-0 fish were limited, suggesting that trap netting is an inefficient method for quantifying age-0 crappie abundance. CPUE was calculated seasonally for each species by lake (Figure 104.5) as well as by fish above and below preferred size (Table 104.3). It is evident that white crappie are dominant over black crappie in most of our sympatric systems, both in total CPUE as well as preferred CPUE.

A comparison of catch rates in the spring to the fall by species and lake was conducted. CPUE was highly variable across seasons within a lake. We believe this was due to the influence of spawning behavior on spring catch rates, with either extremely high or low catches dependent on timing of sampling. This will be tested further with multiple years of data. Mean length-at-age was calculated for each species by lake (Table 104.4). Variation in mean length-at-age should allow for a comparison across lakes. On average, white crappie displayed higher growth rates than black crappie in most lakes, with the difference in length-at-age between the two species increasing with age.

Recommendations:

We will continue to collect data in order to determine variation in crappie recruitment and relate recruitment success to environmental, prey, and predator variables over multiple years. Initial recruitment success will be assessed through larval fish abundance, pooling black and white crappie because of difficulties distinguishing the two (Siefert 1969). We will identify critical stages for crappie survival and determine which factors are important to recruitment. These data will be used to recommend management strategies for use in enhancing and evaluating crappie recruitment.

We will continue to evaluate fluctuating crappie recruitment patterns in a number of lakes and identify factors that are responsible. Study lakes were selected to encompass lakes with both good and poor recruitment in order to assess which factors have the greatest effect on year-class strength. Future analyses will incorporate multiple developmental stages (spawning stock, larvae, and age-0 juveniles) in order to evaluate which stages are most crucial for recruitment in Illinois systems. Furthermore, we will evaluate the influence of environmental factors and spawning stock characteristics on crappie recruitment. Collection and analysis of environmental variables are ongoing. These data will allow recommendations of management practices that will help stabilize crappie populations and increase recruitment to improve fishing. We also plan to conduct an analysis of environmental variables in Illinois lakes to better understand the underlying mechanisms that lead to one species of crappie dominating over the other.

We will evaluate the efficiency of sampling gear (fall trap netting vs. fall electrofishing) and time of year (spring vs. fall) for estimating adult crappie abundance in Illinois lakes. Our initial analysis suggests that spring sampling can result in erratic numbers, as sampling may be biased by larger fish moving shallow to spawn. Sampling difficulties have been a reoccurring issue with estimating crappie abundance (e.g. Miranda et al. 1990; Maceina and Stimpert 1998). In the next segment, we will evaluate the variation between gear type and season and its effect on spawning stock abundance estimates. We will also be testing the capture efficiency of a modified trawl on age-0 to age-2 crappie in order to supplement trap net data. These data will allow recommendations of sampling techniques for both juvenile and adult crappie in Illinois lakes.

Study 105: Sportfish Sampling Efficiency

Job 105.1: Comparison of AC and DC electrofishing for sampling fish populations in Illinois lakes.

Objectives: To evaluate differences in catch rate and efficiency for sportfish sampling with AC and DC electrofishing gears.

Introduction:

Electrofishing is a common tool used by biologists to sample fish populations. There are multiple gear types and settings that can be used when electrofishing and different reasons for using each. Traditionally the IDNR has used AC electrofishing for standardized sampling of fish populations in lakes throughout the state. However the use of DC electrofishing is becoming more common as the costs are declining and the benefits are better understood. DC electrofishing has been shown to be more efficient for use with certain fish species and biologists have begun using this gear more often. There is a need for research comparing these two gear types in order to determine if comparisons can be made and to develop standardized sampling. These comparisons are critical for using historical data for observing long-term trends. In addition more information is needed regarding the efficiency and limitations of each gear type and how it differs with each fish species.

Electrofishing is one of the most common gears employed for sampling of littoral fish populations. Electrofishing gear can employ three types of current to immobilize fish, alternating current (AC), direct current (DC) or pulsed direct current (PDC). The accepted generality is that AC has the greatest level of mortality for fish, followed by PDC and finally DC (Hauck 1949; Lamarque 1990; Reynolds 1996; Snyder 2003). Although the effects of the different types of gears are universally accepted, there is little research directly comparing the three currents (Snyder 2003).

Lab experiments comparing all three currents found the highest mortality occurred with AC (4%), followed by PDC (0.3%) and no mortality in DC treatments (Taylor et al. 1957). Two additional studies observed higher mortality in a number of fish species when subjected to AC current compared to DC current (Pratt 1955; DeMont 1971). Alternatively, Spencer (1967) found no differences in mortality for bluegill subjected to either 115 V AC or 115 V DC in concrete ponds. Only two studies directly compared differences in injury rates between AC and DC current types and found a slightly higher rate of spinal injuries and muscle hemorrhages in AC treatments (Taube 1992; Spencer 1967). Despite the negative impressions of AC electrofishing, mortality and injury levels are generally reported as low and have been shown to produce no long term decrease in survival or growth compared to other collection techniques (Schneider 1992). Although there are a large number of studies examining the effects of different electrofishing fields and varying settings on fish species, they are difficult to compare and direct comparisons are limited (Snyder 2003). In addition these studies are primarily focused on stream systems and sensitive salmonid species (Snyder 2003) and only recently have included non-game fish (see Miranda and Kidwell 2010; Janac and Jurajda 2011). Electrofishing catch rates of sportfish have been demonstrated to be related to density in reservoirs (Serns 1982; Serns 1983; Hall 1986; Gabelhouse 1987). When pulsed AC catch rates of largemouth bass were compared to pulsed DC in small ponds, it was determined that pulsed AC catch rates were much higher and more directly related to population estimates of largemouth bass (Hill and Willis

1994). To our knowledge, no studies have examined differences in catch rates or efficiency of AC and pulsed DC gear in lakes. There is a need for research to directly compare catch rates of the two gears and determine the advantages and disadvantages of using one over the other.

Procedures:

In previous segments, we conducted electrofishing samples on four lakes using both AC and DC electrofishing gear. In this segment, we expanded the comparison of gears to include 17 lakes distributed throughout Illinois. AC electrofishing was conducted using 240V 3 phase AC generator and two poles with three droppers on each wired in sequence for 3 phase. Pulsed DC electrofishing was conducted using a Smith Root type VI electrofishing box utilizing 2 poles with circular probes containing 8 cable droppers on each at a voltage of 240V adjusting the pulse width to target 6-9A. These setups are the same as those used by biologists in the IDNR and all data collected will be comparable. In this segment we conducted one date of AC and one date DC electrofishing on each lake. AC or DC electrofishing was chosen randomly on each trip to ensure that the order of the gears used varied by lake. We conducted three thirty minute transects on each date and collected all fish species. We took lengths on all species and weights on largemouth bass and crappie. We calculated CPUE of major fish species of interest and compared catch rates of AC to DC gear. Data analysis in this segment focused on the expanded database of 15 lakes sampled in the spring of 2014 and included pairwise comparisons of catch rates to determine if there were significant differences between gear types. We developed relationships between gears and determined what corrections may be required. We will make recommendations for which gear is more appropriate for each species and identify situations where one may be preferred over the other.

Findings:

In this segment we electrofished 15 study lakes with both AC and DC gear in the spring of 2014. Paired t-tests were used to examine differences in CPUE by species between the two gear types. There was no significant differences in catch rates between AC and DC electrofishing for bluegill ($t = 2.14$; $P = 0.07$), gizzard shad ($t = 2.14$; $P = 0.13$), white crappie ($t = 2.14$; $P = 0.93$), or black crappie ($t = 2.14$; $P = 0.53$). CPUE of common carp was significantly higher for DC electrofishing than AC electrofishing ($t = 2.14$; $P = 0.05$; Figure 105.1) and the catch rates were only marginally correlated between the two gears ($r = 0.49$; $P = 0.06$). Common carp tend to avoid electrofishing current and DC has been noted to better draw moving fish toward the dropper array than AC, possibly contributing to the higher catch rates observed.

No significant differences existed between gear types for CPUE of young-of-year largemouth bass ($t = 2.14$; $P = 0.28$), but catch rates of adult largemouth bass were significantly greater in DC than with AC gear ($t = 2.14$; $P = 0.009$; Figure 105.2). In addition, AC and DC electrofishing CPUE was correlated for young-of-year largemouth bass ($r = 0.71$; $P = 0.003$), but only marginally correlated for adult largemouth bass ($r = 0.47$; $P = 0.08$). These results differ from what we observed in previous segments where catch rates were correlated for both young-of-year ($r = 0.60$; $P = 0.006$) and adult largemouth bass ($r = 0.53$; $P = 0.02$) in four lakes sampled for 3 years. Current results suggest with a larger dataset that there may be differences in CPUE and the relative abundances of larger sized largemouth bass when sampling with AC or DC electrofishing. It is unclear if AC electrofishing is underrepresenting adult largemouth bass or if

DC gear is attracting in more fish resulting in over representing them. More data collection is required to make this evaluation.

Recommendations:

Although catch rates for some species examined were similar between AC and DC gears there were species where we observed differences between gears. Largemouth bass catch rates were very similar between gear types for young-of-year fish, but this was not the case for larger largemouth bass. Both adult largemouth bass and common carp had differences in catch rates between AC and DC gear and gears were not significantly related. Of the fish examined, these were the largest fish. DC gear may work better with larger fish that can generally escape the AC electric field prior to being netted. DC gear will attract larger fish and may prevent escape of better swimming fish or those with larger body size. We will examine size biases of the gears for other species in more detail in future segments. White and black crappie catch rates were not consistent results from past segments, but catch rates in general were low. Based on data from Job 104.3, electrofishing is not the preferred method for assessing crappie populations and due to differences in gear types from year to year, it is evident that electrofishing is not representing their population accurately.

Analyses in future segments will focus on if differences observed thus far are significant and if conclusions on the status of a fishery would be biased by gear selection. It is unclear if higher catch rates of some species with DC gear is a better representation of the population than with AC gear. The gear of choice may depend on management goals and attempting to target larger fish, or certain species, there are benefits of using DC electrofishing. More research is required to determine which gear better represents population size structure. We will expand the analyses to include more species and examine size distribution differences between gear types. We will determine if the IDNR can compare data collected with DC gear to historical data collected using AC gear and identify areas where discrepancies may occur. We will include additional seasons and years of data for the 15 study lakes to increase the analytical power of our comparisons. Recommendations on the use of AC or DC gear will be based on the species of interest and the tradeoffs of each gear. Ultimately this information will guide the IDNR in development of sampling protocols and allow for changes in gear type that allow comparison with historical data.

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Table 101.1: Stocking information for four lakes stocked with largemouth bass both at the boat ramp and dispersed into habitat throughout the lake. CPUE is catch per hour from electrofishing transects conducted in the fall after stocking and the subsequent spring.

Lake	Stocking Date	Boat Ramp Stocking			Dispersed Stocking		
		# Stocked	Fall CPUE	Spring CPUE	# Stocked	Fall CPUE	Spring CPUE
Charleston	8/15/2008	3500	2.0	0.0	3500	2.0	0.4
	8/25/2009	3500	0.8	0.0	3500	0.0	0.0
	9/2/2010	3500	1.0	0.0	3500	1.7	0.0
	8/12/2011	3500	0.7	0.0	3500	1.1	0.0
	8/3/2012	3500	0.7	0.0	3500	0.0	0.0
	8/12/2013	3500	0.0	0.0	3500	0.0	0.0
Homer	8/16/2007	1400	0.3	0.0	1400	0.3	0.0
	8/24/2009	1000	0.3	0.0	1000	0.0	0.0
	8/26/2010	1000	1.4	0.0	1000	0.0	0.3
	8/11/2011	1000	2.7	0.3	1000	2.3	0.7
	8/3/2012	1000	1.7	0.3	1000	1.0	0.0
	8/12/2013	1000	1.3	0.0	1000	2.0	0.0
Mingo	8/16/2007	3400	0.7	0.0	3400	2.0	0.0
	8/14/2008	2150	5.7	0.0	2150	3.7	0.7
	8/24/2009	2125	0.0	0.0	2125	0.3	0.0
	8/26/2010	2125	1.3	0.0	2125	0.3	0.0
	8/11/2011	2125	0.0	0.0	2125	0.0	0.3
	8/3/2012	2125	0.3	0.0	2125	0.0	0.0
	8/12/2013	2125			2125	0.3	0.0
			0.0	0.0			
Otter	8/15/2007	7650	0.2	0.0	7650	0.0	0.0
	8/13/2008	11400	0.8	0.0	11400	0.2	0.0
	8/25/2009	7650	0.4	0.2	7650	0.0	0.0
	8/25/2010	7650	0.2	0.2	7650	0.4	0.0
	8/15/2011	7650	0.8	0.0	7650	1.6	0.2
	8/2/2012	7650	0.0	0.0	7650	0.8	0.0
	8/13/2013	7650	0.2	0.0	7650	0.0	0.2
Mean Total			0.9	0.0		0.8	0.1

Table 101.2: Environmental variables averaged across all ponds and sampling dates for experimental ponds used to evaluate growth and survival of white, black, and blacknose crappie.

Variable	Mean (Range)	Standard Error
Turbidity (NTU)	11.35 (6.28-25.20)	1.19
Phosphorous (μg/L)	55.07 (33.69-92.06)	2.99
Chlorophyll-a (μg/L)	8.95 (3.88-16.84)	0.76
Total vegetation (g/m^2)	431 (154-705)	31
Total macroinvertebrate density ($\#/m^3$)	9,021 (2,748-13,492)	700
Total dipteran larva density ($\#/m^3$)	5,917 (1,797-9,318)	477
Rotifer density (#/L)	203 (32-656)	31
Copepod density (#/L)	127 (78-166)	5
Cladoceran density (#/L)	13 (2-33)	2
Total zooplankton density (#/L)	442 (204-827)	33

Table 101.3: Best species-specific multiple regression models for change in weight of black (BLC), white (WHC) and blacknose (BNC) crappie in experimental ponds as determined by Δ AIC model selection. Available variables for inclusion were total zooplankton density (#/L, Zoop), turbidity (NTU, Turb), and phosphorous (μg/L, Phos).

Species	Model	RMSE	Model R^2	Δ AIC
BLC	Zoop + Turb	1.50	0.99	--
	Zoop + Turb + Phos	1.57	0.99	1.7
BNC	Zoop	2.78	0.96	--
	Zoop + Turb	2.74	0.97	0.5
	Zoop + Phos	2.93	0.96	1.9
WHC	Zoop	2.21	0.95	--
	Zoop + Phos	2.34	0.95	1.9
	Zoop + Turb	2.34	0.95	2.0

Table 102.1: Largemouth bass regulation summary of the 488 lakes listed in the IDNR Regulation booklet. Lakes were grouped as those that had no regulation change or those where the regulation was modified in the period from 2007 to 2013. Lakes with FAS data are those that were sampled by DNR biologists between 2007 and 2013.

Regulation	Lakes in 2013	No Regulation Change		Regulation Change		
		Number of Lakes	Lakes With FAS Data	Prior to Change	After Change	Lakes With FAS Data
Catch and Release	5	4	1	0	1	0
Lowered Bag	30	25	12	6	5	1
Lowered Length	6	4	0	0	2	1
No L	154	146	19	38	8	1
Over Under	5	2	1	0	3	2
Raised Length	46	44	22	3	2	1
Raised Length Lowered Bag	140	108	50	10	32	14
Slot	27	19	7	1	8	0
Standard	75	74	47	4	1	0
Total	488	426	159	62	62	20

Table 102.2: Crappie regulation summary of the 488 lakes listed in the IDNR Regulation booklet. Lakes were grouped as those that had no regulation change or those where the regulation was modified in the period from 2007 to 2013. Lakes with FAS data are those that were sampled by DNR biologists between 2007 and 2013.

Regulation	Lakes in 2013	No regulation Change		Regulation Change		
		Number of Lakes	Lakes With FAS Data	Prior to Change	After Change	Lakes With FAS Data
Bag	47	26	11	3	21	2
Catch and Release	1	1	1	0	0	0
Length	1	1	0	0	0	0
Length and Bag	42	33	19	17	9	4
None	380	376	92	29	4	0
Over Under	17	2	2	0	15	4
Total	488	439	125	49	49	10

Table 102.3: Lake characteristics for Ridge Lake in 2006 – 2013 in years with spring largemouth bass tournaments and years that were closed to fishing.

Year	Type	Mean Fall Electrofishing CPUE (#/hour)			Larval Fish Density (#/L)	Zooplankton Density (#/L)	Benthos Density (#/m2)
		YOY LMB (<200mm)	BLG	LMB >200mm			
2014	Closed	NA	NA	NA	NA	NA	NA
2013	Tournament	58.9	54.1	28.6	2.7	497.8	3330.8
2012	Closed	27.0	58.1	20.9	0.5	385.4	18695.7
2011	Closed	12.0	69.9	42.9	1.4	612.1	936.2
2010	Tournament	18.1	66.0	15.6	3.4	135.1	10065.6
2009	Closed	52.5	80.6	19.2	9.2	1150.7	5127.3
2008	Closed	39.2	96.8	49.9	0.1	458.8	11502.1
2007	Tournament	59.2	67.2	52.3	1.2	399.4	7563.5
2006	Closed	29.1	50.8	41.0	0.5	352.2	3859.9

Table 102.4: The total tournament activity for 12 lakes in Illinois where all activity is thought to be known. Lakes were categorized based on angler hours per acre.

Lake	Size	Category	Angler Hours Per Acre	Total Number of Anglers	Total Hours of Tournaments	Total Number of Bass Weighed In	Total Weight of Bass Weighed In
Bloomington	635	High	3.3	335	54	228	575
Charleston	317	None	0.0	0	NA	NA	NA
Clinton	4895	Low	0.1	246	16	65	187
Coffeen	1070	High	4.2	706	113	1251	2435
Evergreen	925	Low	2.0	269	52	182	472
Forbes	542	Low	0.4	356	11	91	200
Jacksonville	442	High	7.3	972	176	1240	3380
Lincoln Trail	137	None	0.0	0	NA	NA	NA
Mattoon	988	Low	0.8	155	32	106	257
Paradise	138	None	0.0	0	NA	NA	NA
Sangchris	2321	Low	0.4	1479	20	79	516
Shelbyville	11100	Low	1.9	2641	364	2689	5932
Walnut Point	52	None	0.0	0	NA	NA	NA

Table 102.5: Mean tournament demographics for 12 lakes in Illinois where tournament results have been obtained.

Lake	Mean Tournaments Reported	Number of Anglers Per Tournament	Mean Length of Tournament (hrs)	Number of Fish Weighed in per Tournament	Mean Big fish Weight (lbs)	Mean Weight per fish Weighed In (lbs)	Catch Per Angler	Catch Per Angler Per Hour
Bloomington	9.6	36.3	6.2	35.1	4.65	2.52	0.98	0.16
Clinton	6.0	29.8	5.1	23.0	4.73	3.04	0.87	0.21
Coffeen	31.8	48.3	7.5	82.0	4.24	2.11	1.84	0.25
Dawson	3.3	20.1	3.3	3.6	3.24	2.15	0.19	0.07
Evergreen	8.7	33.7	6.2	32.4	4.96	2.65	0.92	0.14
Forbes	9.2	32.4	7.1	23.7	5.00	2.21	1.00	0.23
Jacksonville	47.4	22.3	8.1	42.2	5.52	2.83	1.96	0.24
Mattoon	6.7	22.8	4.6	16.4	4.65	2.53	0.71	0.16
Mill Creek	36.6	38.2	.	45.6	5.23	2.29	1.26	.
Rend	27.0	57.8	8.3	83.5	5.06	2.23	1.46	0.18
Sangchris	33.6	37.4	7.8	52.3	3.52	1.94	1.86	0.24
Shelbyville	45.7	58.1	8.1	63.0	5.35	2.22	1.10	0.14

Table 103.1: Vegetated area and perimeter for all vegetation experimental lakes in spring and fall assessments in 2013.

Lake	Type	Lake Area (m^2)	Lake Perim. (m)	Area Vegetated				Percent of Lake Vegetated			
				Spring		Fall		Spring		Fall	
				Area (m^2)	Perim. (m)	Area (m^2)	Perim. (m)	Area (%)	Perim. (%)	Area (%)	Perim. (%)
Airport	Removal	89246	1171	12738	1173	13787	1171	14	100	15	100
Charleston	Control	1363953	5834	26995	5703	28277	4736	2	98	2	81
Dolan	Drawdown	302869	5335	54119	4283	79861	2185	18	80	26	41
Forbes	Control	2056612	29364	317600	26165	183913	26633	15	89	9	91
Lincoln	Control	584546	10033	118732	9496	90908	9391	20	95	16	94
Paradise	Planted	706098	7287	42960	4028	29947	4206	6	55	4	58
Pierce	Control	647830	6406	180546	6424	119534	5919	28	100	18	92
Ridge	Control	44013	1132	23275	1241	19630	1452	53	100	45	100
Stillwater	Removal	89363	2215	51410	2222	4163	2042	58	100	5	92
Walnut	Control	215810	9396	4445	1284	7055	3755	2	14	3	40

Table 103.2: Catch per unit effort from fall electrofishing samples and percent vegetation area and perimeter from fall vegetation assessments from Dolan Lake in 1998-2013. The lake was drawn down and rotenone treated to remove common carp and gizzard shad in 2006.

Year	Bluegill	Gizzard Shad	Common Carp	YOY LMB	Adult LMB	Fall Veg Area %	Fall Veg Perim %
			PRE TREATMENT				
2001	104.0	12.3	0.0	15.0	11.7	0.0	0.0
2002	Not Sampled in Fall Due to Drawdown.					1.7	7.7
2003	200.0	21.3	2.7	5.3	7.3	1.1	1.1
2004	89.7	7.0	0.7	4.7	8.7	NA	NA
2005	224.0	16.0	1.3	4.7	2.7	4.1	17.3
Mean	**154.4**	**14.2**	**1.2**	**7.4**	**7.6**	**1.7**	**6.5**
			TREATMENT				
2007	58.7	0.0	0.0	26.0	37.3	25.5	76.2
2008	42.7	0.7	0.0	25.3	60.7	20.0	97.0
2009	45.7	0.7	0.0	6.0	48.0	18.5	90.5
2010	26.0	7.0	0.0	6.7	60.0	25.8	84.4
2011	51.3	27.3	0.0	9.0	33.0	15.7	79.7
2012	99.2	108.3	0.0	10.5	48.7	15.5	74.2
2013	102.0	26.0	0.0	2.7	22.3	26.0	41.0
Mean	**60.8**	**24.3**	**0.0**	**12.3**	**44.3**	**21.0**	**77.6**

Table 103.3: Largemouth bass CPUE separated into young-of-year less than 200 mm (YOY) and adult fish greater than 199 mm (adult) from fall electrofishing samples in three lakes where vegetation was manipulated. In addition, the percent of the lake area and the percent of the lake perimeter that contained vegetation were calculated through GPS mapping. Lake treatments were chemical treatment to remove vegetation (Removal), planting to increase vegetation (Planting) and conditions before treatment (Pre).

Lake	Year	Treatment	YOY LMB CPUE	Adult LMB CPUE	% Area Vegetated	% Perimeter Vegetated
Airport	2007	Pre	22.2	33.3	100	100
Airport	2008	Pre	68.2	13.0	100	100
Airport	2009	Pre	25.8	3.0	100	100
Airport	2010	Removal	10.8	6.1	100	100
Airport	2011	Removal	12.4	29.3	100	100
Airport	2012	Removal	3.6	5.5	20	100
Airport	2013	Removal	5.0	3.6	15	100
Stillwater	2007	Pre	26.2	13.7	100	101
Stillwater	2008	Pre	5.1	14.8	100	100
Stillwater	2009	Pre	30.5	5.3	100	100
Stillwater	2010	Removal	41.1	10.6	1	10
Stillwater	2011	Removal	19.1	23.6	21	100
Stillwater	2012	Removal	1.6	9.8	78	100
Stillwater	2013	Removal	1.9	8.7	5	92
Paradise	2007	Pre	9.3	18.0	13	51
Paradise	2008	Planting	10.0	13.0	1	12
Paradise	2009	Planting	18.2	19.0	5	40
Paradise	2010	Planting	14.7	36.0	12	58
Paradise	2011	Planting	5.3	23.7	3	43
Paradise	2012	Planting	5.7	29.7	2	59
Paradise	2013	Planting	3.3	10.3	4	58

Table 103.4: Percent of sample sites in each substrate class, with wood present and their channel position that were electrofished in the Upper and Middle Kaskaskia Rivers in the fall of 2013 and the spring and summer of 2014.

Segment	Substrate				Wood Present	Channel Position			
	Silt	Sand	Gravel	Cobble		Run Shoreline	Run Middle	Outside Bend	Inside Bend
Middle Kaskaskia	29	14	29	29	57	71	14	14	0
Upper Kaskaskia	31	41	17	10	59	38	24	24	14

Table 104.1: Catch per unit effort of largemouth bass in refuge and non-refuge (lake) sites in Otter Lake from electrofishing samples performed in 2007-2014. Samples were collected prior to the implementation of the refuge (A) and after the two refuges were closed to angling (B).

A: Pre Refuge

Year	Season	Refuge	Lake
2007	FALL	13.1	24.6
2008	SPRING	9.1	15.2
2008	FALL	18.4	22.6
2009	SPRING	12.6	15.0
2009	FALL	24.4	31.4
2010	SPRING	13.8	19.8
Mean		15.2	21.4

B: Post Refuge

Year	Season	Refuge	Lake
2010	FALL	13.3	18.3
2011	SPRING	9.8	15.4
2011	FALL	17.6	22.8
2012	SPRING	12.4	16.2
2012	FALL	13.6	20.0
2013	SPRING	7.4	13.6
2013	FALL	17.2	31.4
2014	SPRING	10.0	20.9
Mean		12.7	19.8

Table 104.2: Density of fish captured from seine hauls conducted inside 2 refuges and in 3 control sites in Otter Lake.

Year	Control Seine Density (#/m2)				Refuge Seine Density (#/m2)			
	Total	LMB	BLG	GZS	Total	LMB	BLG	GZS
Pre Refuge								
2007	0.14	0.03	0.17	0.00	0.23	0.02	0.21	0.00
2008	0.27	0.02	0.28	0.00	0.10	0.00	0.13	0.00
2009	0.06	0.00	0.08	0.00	0.29	0.27	0.15	0.00
2010	0.10	0.02	0.09	0.00	0.05	0.00	0.05	0.00
Pre Mean	0.14	0.02	0.15	0.00	0.17	0.07	0.14	0.00
Post Refuge								
2011	0.02	0.00	0.02	0.00	0.05	0.01	0.03	0.01
2012	0.07	0.01	0.05	0.00	1.54	0.00	0.12	0.00
2013	0.28	0.02	0.22	0.01	0.37	0.01	0.10	0.08
2014	0.57	0.03	0.06	0.00	0.08	0.00	0.06	0.00
Post Mean	0.23	0.01	0.09	0.00	0.51	0.00	0.08	0.02

Table 104.3: Mean CPUE of black crappie (BLC) and white crappie (WHC) that are below (Stock) and above (Preferred) the AFS preferred length in Illinois lakes (N=10).

Lake	BLC				WHC			
	Spring		Fall		Spring		Fall	
	Stock	Preferred	Stock	Preferred	Stock	Preferred	Stock	Preferred
Charleston	5.15	0.45	4.35	0.10	9.35	11.80	16.60	2.20
Clinton	5.45	1.25	5.95	0.75	3.75	0.35	1.50	0.28
Forbes	0.00	0.00	0.00	0.00	10.56	1.00	11.55	0.90
Lincoln	0.69	0.31	0.70	0.05	0.03	0.00	0.00	0.15
Mattoon	0.60	0.10	0.25	0.00	51.05	16.80	34.40	1.45
Mill	6.25	3.85	0.90	0.95	4.55	7.85	1.55	2.10
Paradise	0.06	0.00	0.00	0.00	17.28	1.44	42.05	1.30
Pierce	8.80	3.25	2.10	0.45	0.50	0.60	0.40	0.00
Shelbyville	3.40	0.17	10.38	5.53	3.15	4.30	12.35	7.85
Springfield	0.11	0.00	1.89	0.06	0.00	0.00	0.00	0.00

Table 104.4: Mean length-at-age for black crappie (BLC) and white crappie (WHC) for ages 1 through 6. Missing ages indicate no individuals were captured at that age in our subsample in Illinois lakes (N=9).

Lake	BLC						WHC					
	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6	Age-1	Age-2	Age-3	Age-4	Age-5	Age-6
Charleston	171.7	158.0	192.3	212.7	218.0	245.0	172.2	215.6	244.1	270.4	257.0	301.7
Clinton	177.9	220.2	227.1	260.8	254.8	260.0	197.2	225.4	246.5	-	-	-
Lincoln	-	231.0	268.0	297.0	-	-	171.7	191.7	203.1	217.5	274.0	350.0
Mattoon	171.0	-	214.8	-	-	-	176.6	210.4	222.7	257.4	265.5	281.0
Mill	-	206.5	226.7	247.7	-	253.0	-	-	-	243.3	263.8	298.8
Paradise	-	-	-	-	-	-	153.0	159.0	176.5	217.9	210.7	247.0
Pierce	-	184.5	230.4	264.6	-	298.0	-	200.3	266.7	-	-	-
Shelbyville	153.6	201.2	218.5	232.1	-	227.0	170.8	219.5	257.2	268.0	-	-
Springfield	-	233.0	246.0	271.6	-	-	-	237.4	256.5	267.3	-	308.0

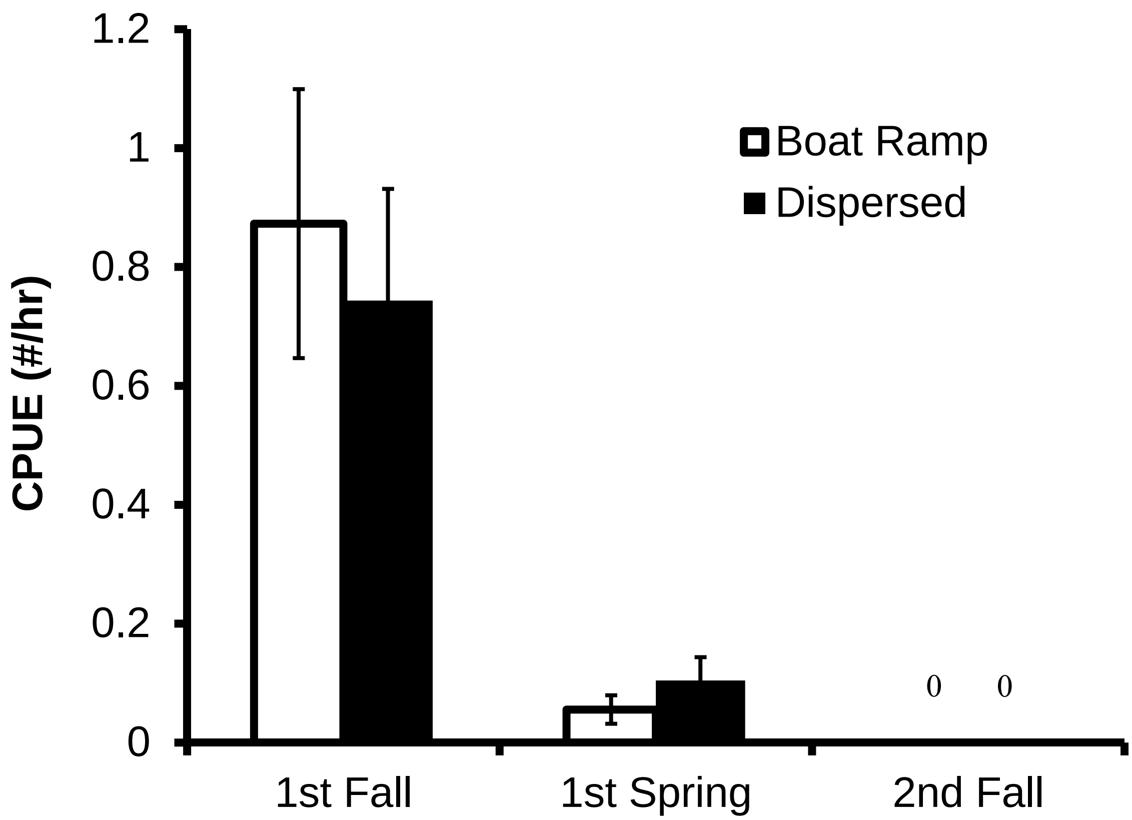

Figure 101.1: Mean CPUE of largemouth bass from Fall and Spring electrofishing samples following stocking at either boat ramp or dispersed stockings from 2008-2013.

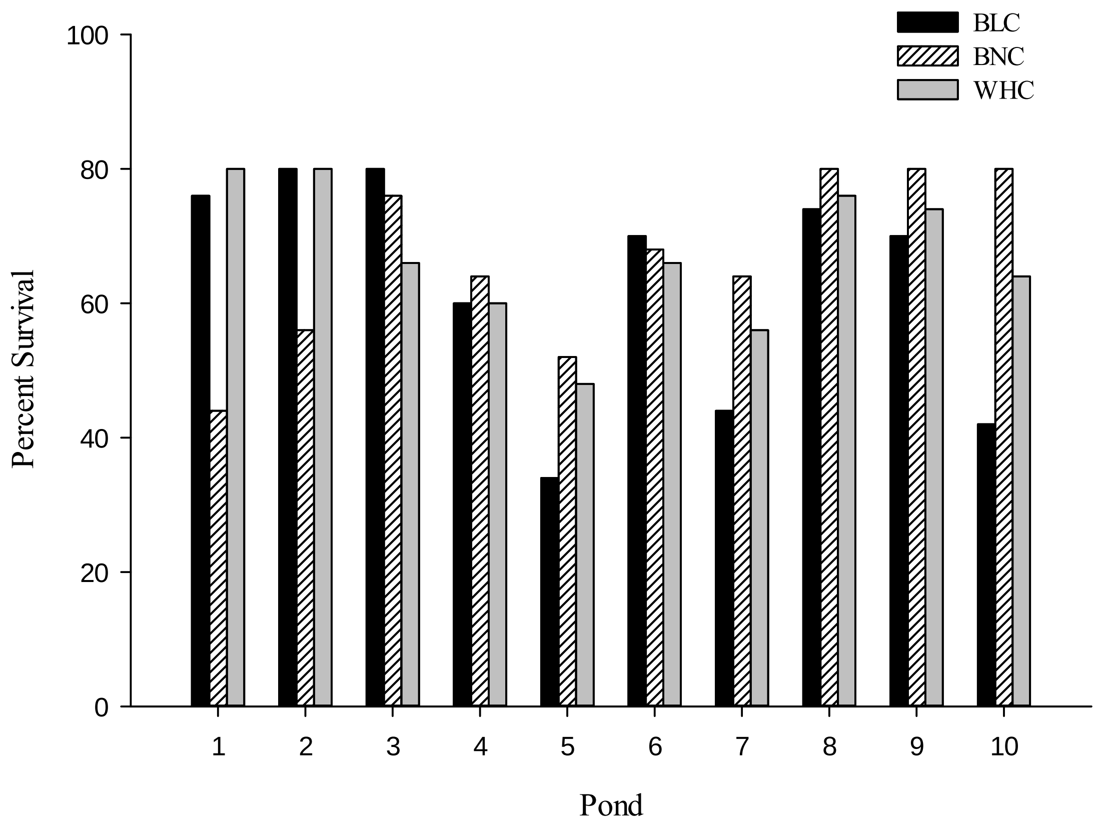

Figure 101.2: Percent survival of juvenile black (BLC), blacknose (BNC), and white (WHC) crappies stocked into each experimental pond.

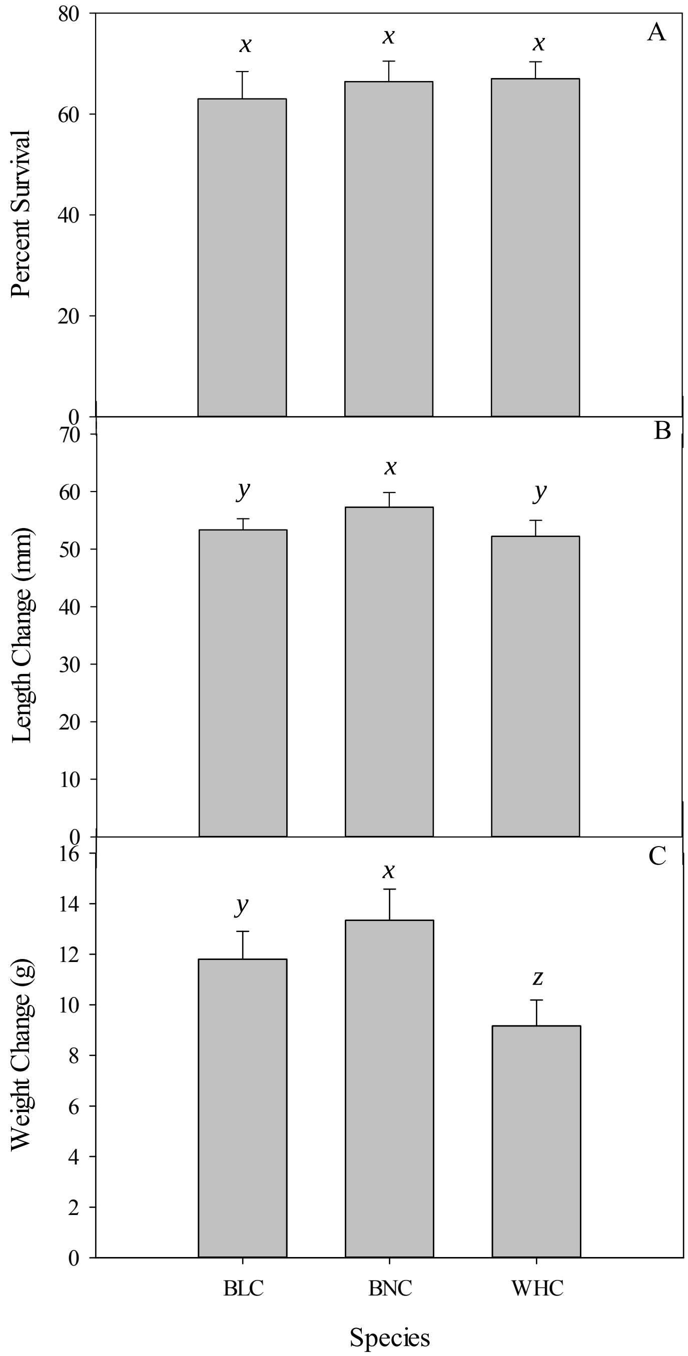

Figure 101.3: Average survival (A), change in length (B), and change in weight (C) of juvenile black (BLC) blacknose (BNC) and white (WHC) crappies across all ponds. Error bars represent standard errors and lowercase letters indicate significant differences among species.

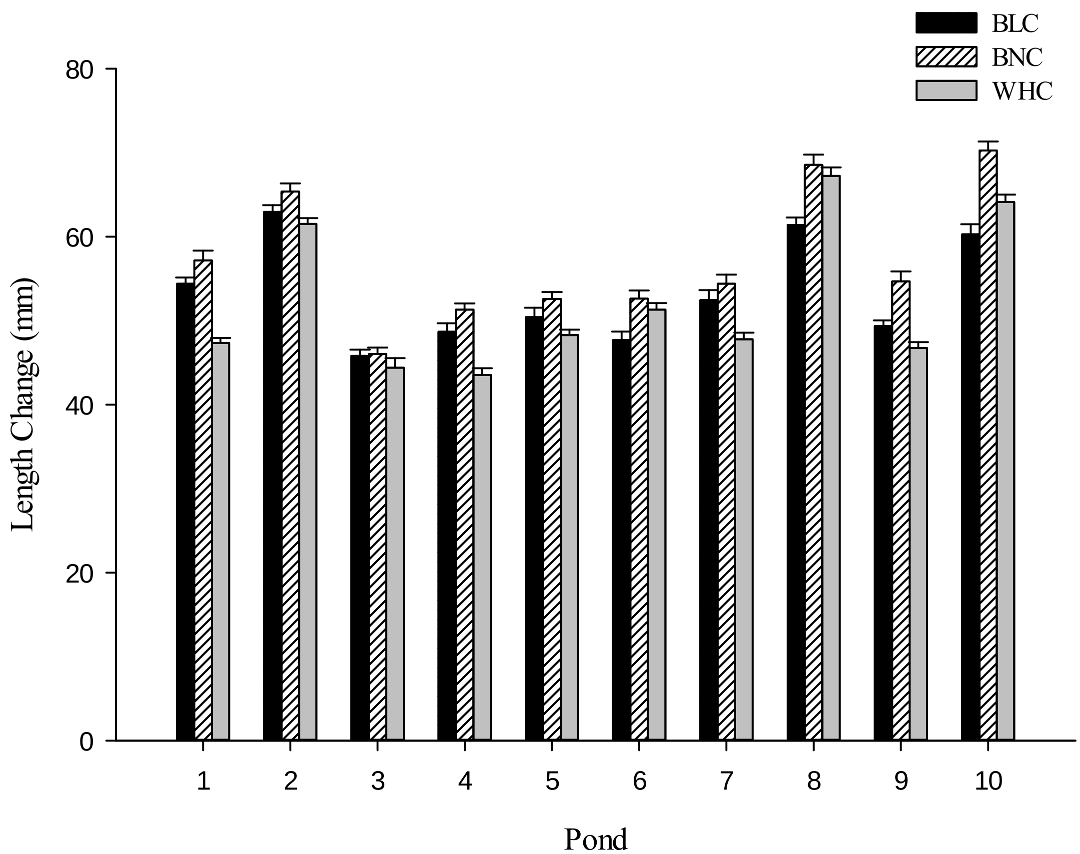

Figure 101.4: Change in length of juvenile black (BLC), blacknose (BNC), and white (WHC) crappies stocked into each experimental pond after a three month growth period. Error bars represent standard errors.

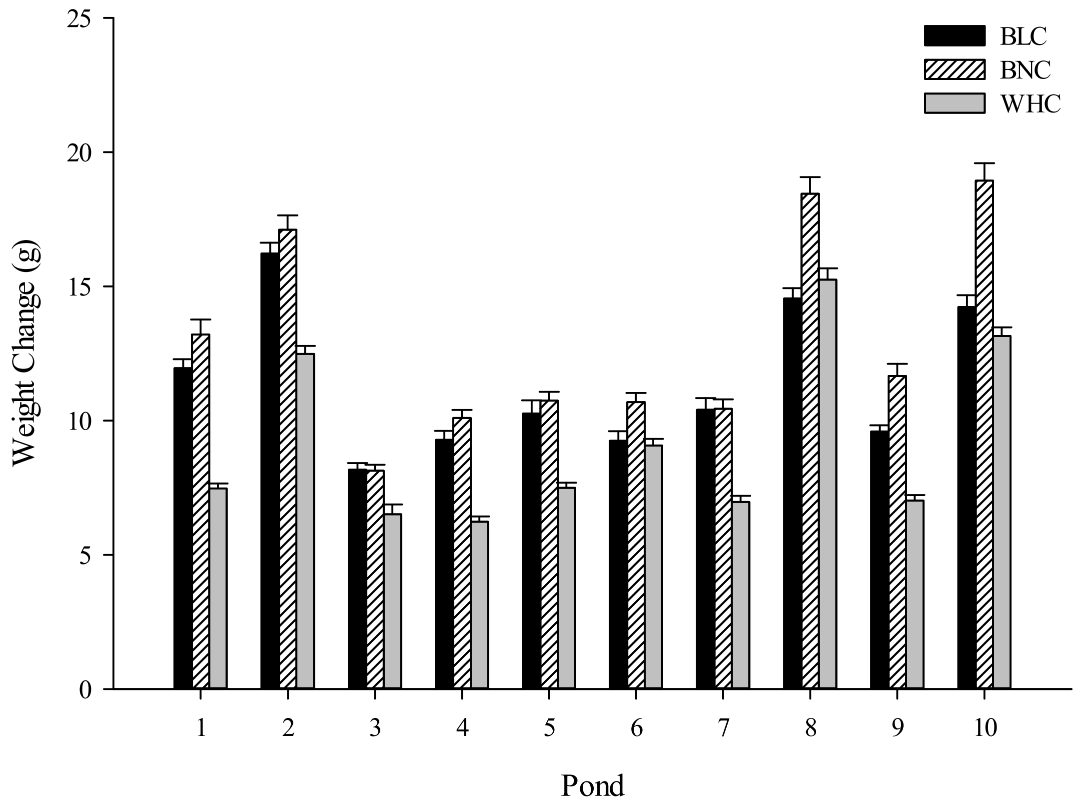

Figure 101.5: Change in weight of juvenile black (BLC), blacknose (BNC), and white (WHC) crappies stocked into each experimental pond after a three month growth period. Error bars represent standard errors.

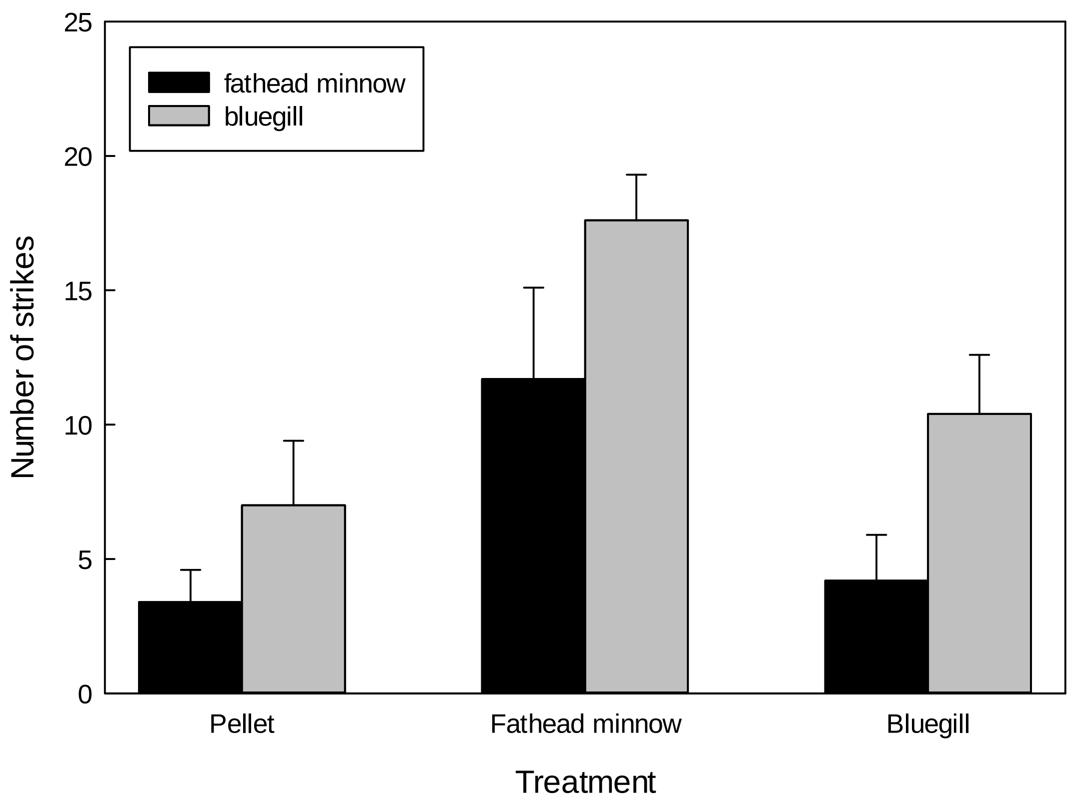

Figure 101.6: The number of strikes made by largemouth bass acclimated on pellet, fathead minnow or bluegill prey in experimental trials with bluegill or fathead minnow prey.

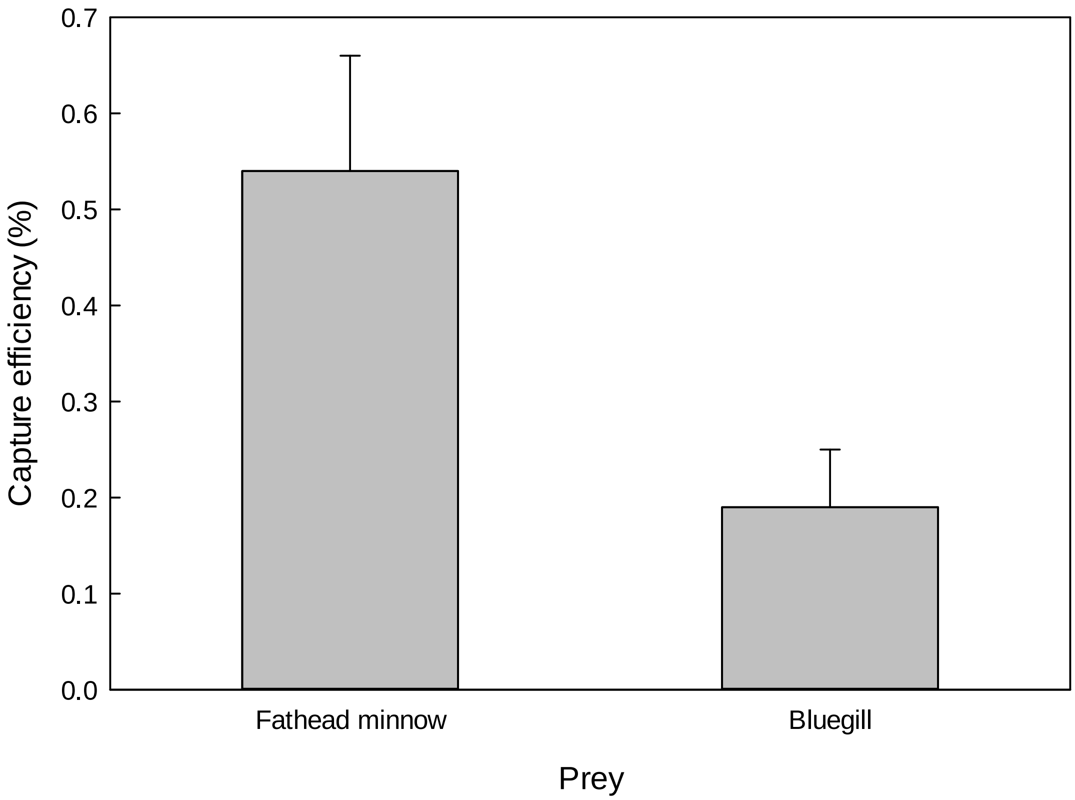

Figure 101.7: Capture efficiencies from tank experiments across largemouth bass acclimated on three prey types. Capture efficiency is the number of prey captures divided by the number of strikes.

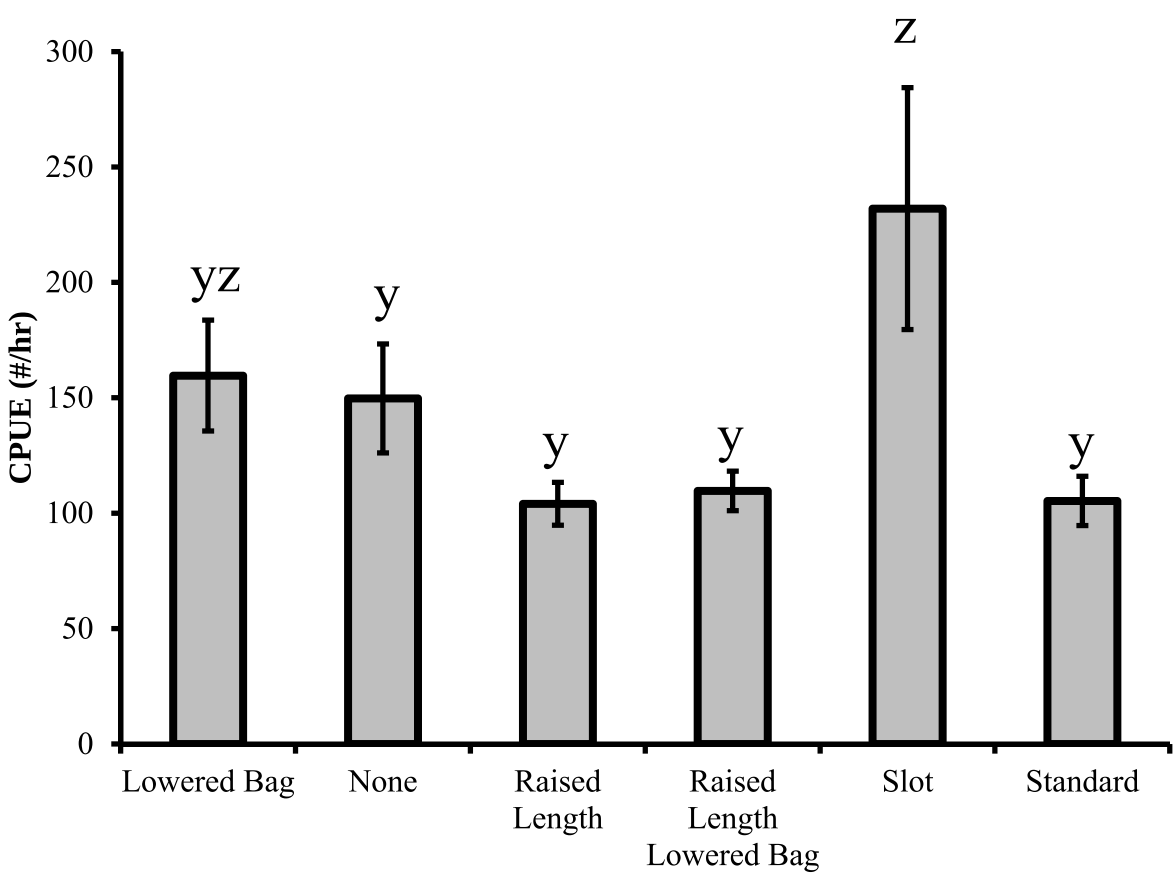

Figure 102.1: Mean catch per unit effort for all largemouth bass from electrofishing samples from 2007 through 2013 conducted by the Illinois DNR and entered into the FAS database. Catches are categorized by the type of regulation in place on each lake. Similar letters indicate bars that are not significantly different.

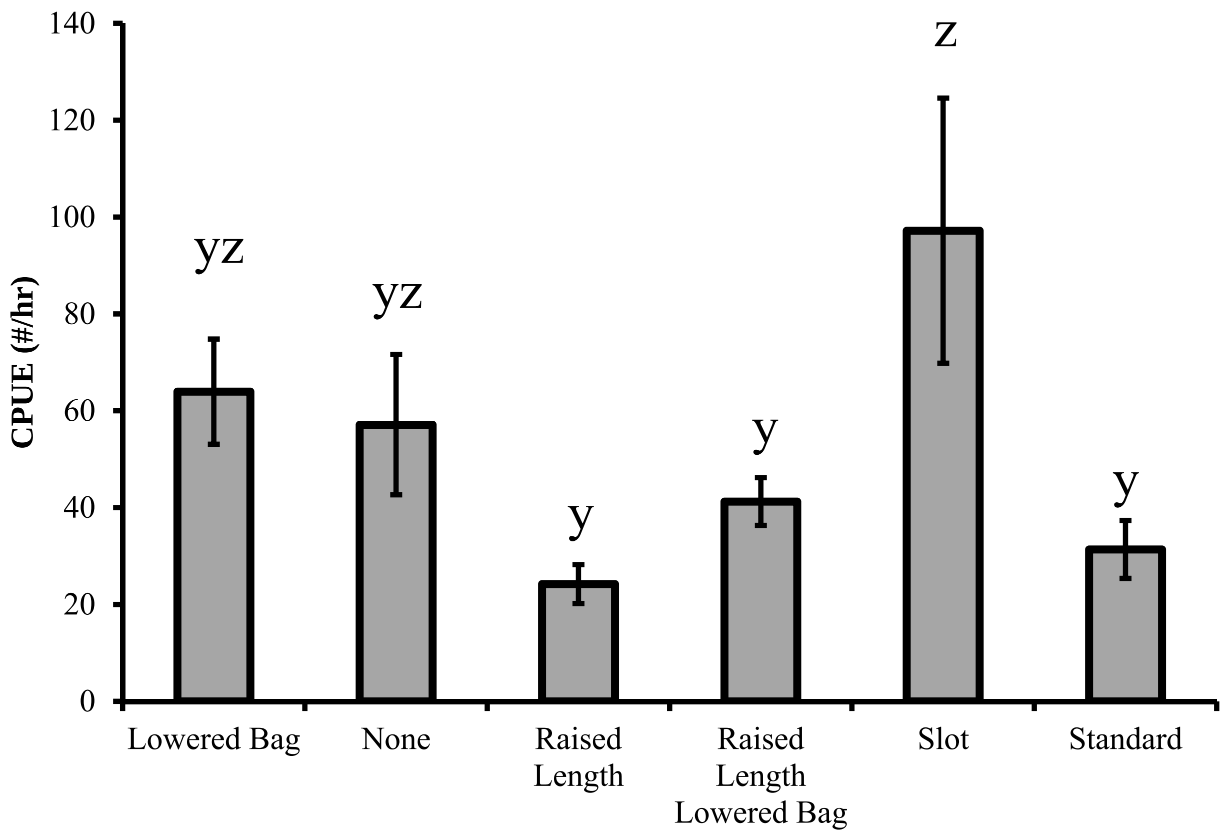

Figure 102.2: Mean catch per unit effort for all young-of-year largemouth bass in electrofishing samples from 2007 to 2013 conducted by the Illinois DNR and entered into the FAS database. Catches are categorized by the type of regulation in place on each lake. Similar letters indicate bars that are not significantly different.

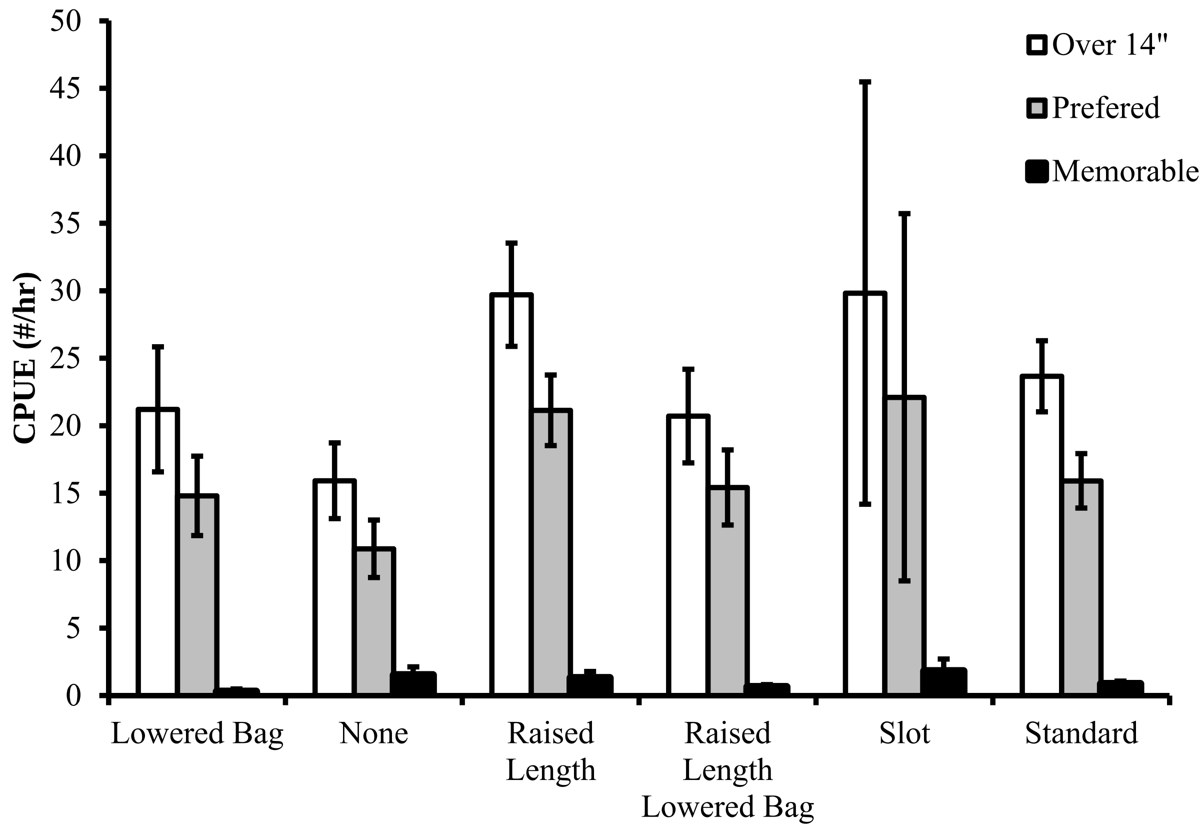

Figure 102.3: Mean catch per unit effort for largemouth bass over 14-inches in length, preferred size, and memorable length from electrofishing samples from 2007 to 20013 conducted by the Illinois DNR and entered into the FAS database. Catches are categorized by the type of regulation in place on each lake.

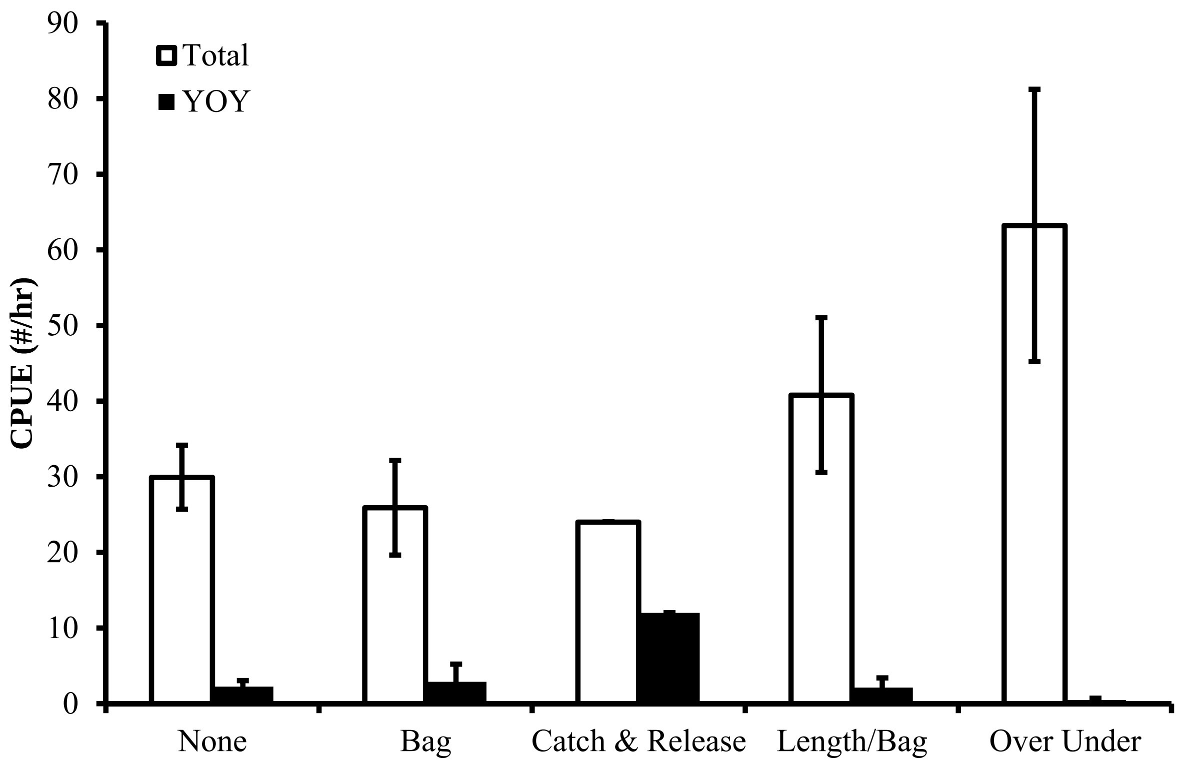

Figure 102.4: Mean catch per unit effort (CPUE) of all sizes of black and white crappie (total), and for young-of-year (YOY) from electrofishing samples conducted by IDNR biologists from 2007-2013 on Illinois Lakes with varying regulations. Error bars represent the standard error.

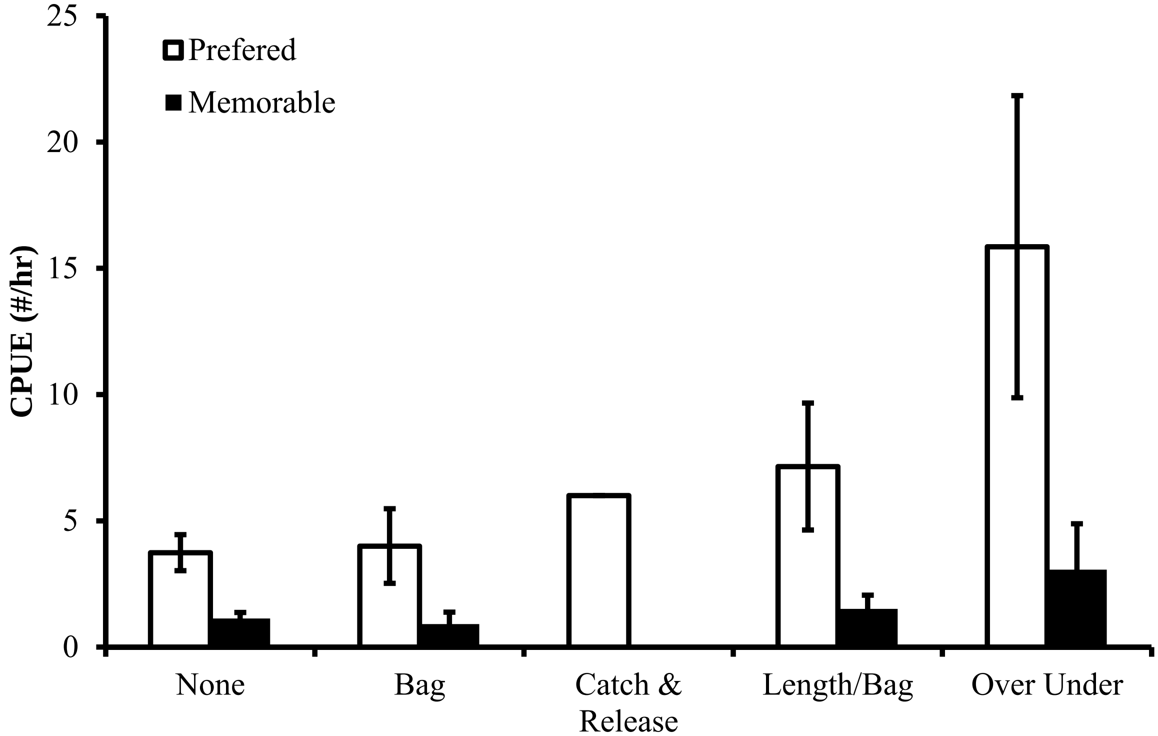

Figure 102.5: Mean catch per unit effort (CPUE) of black and white crappie combined of preferred size (250 – 299 mm) and memorable size (300 – 380 mm) from electrofishing samples conducted by IDNR biologists from 2007-2013 on Illinois Lakes with varying regulations. Error bars represent the standard error.

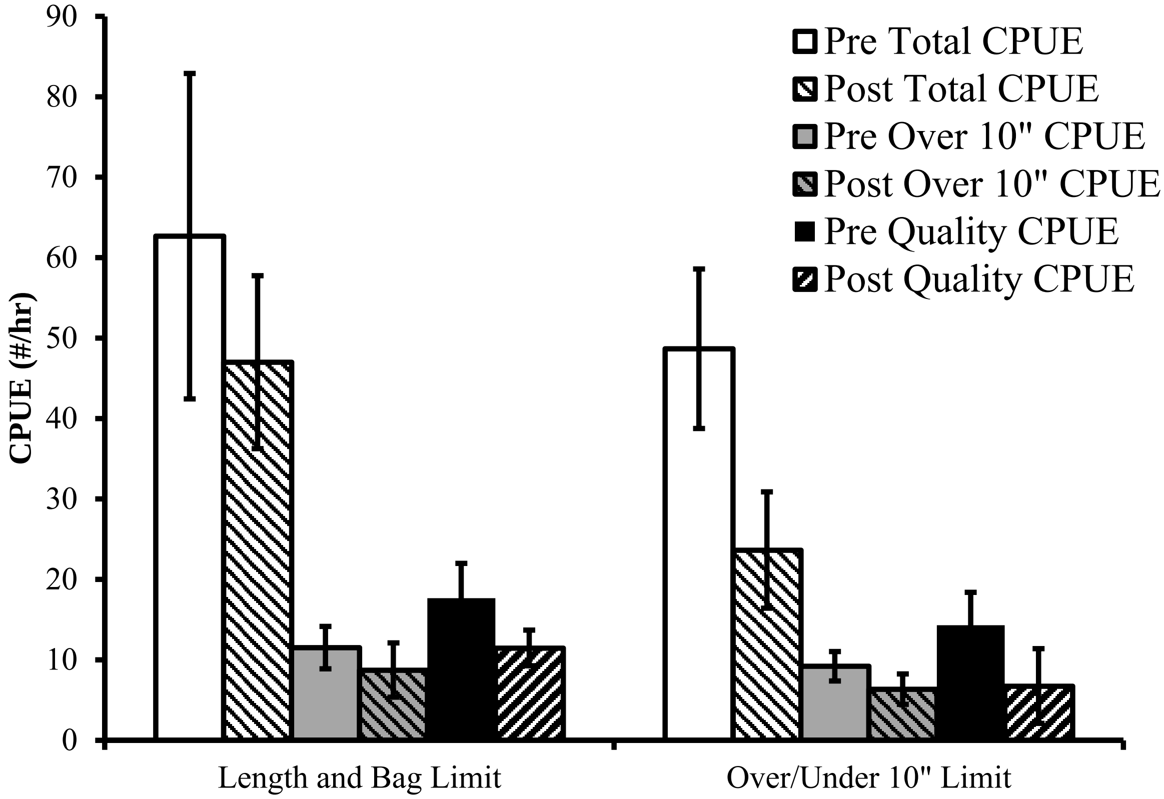

Figure 102.6: Mean catch per unit effort (CPUE) of black and white crappie combined for all sizes (total CPUE), CPUE of fish over 10 inches, and CPUE of Quality fish (8-10 inches) from electrofishing samples conducted by IDNR biologists from 2007-2013 on Illinois Lakes with regulation changes. Samples were collected before the regulation change (Pre) and following the regulation change (Post). Error bars represent the standard error.

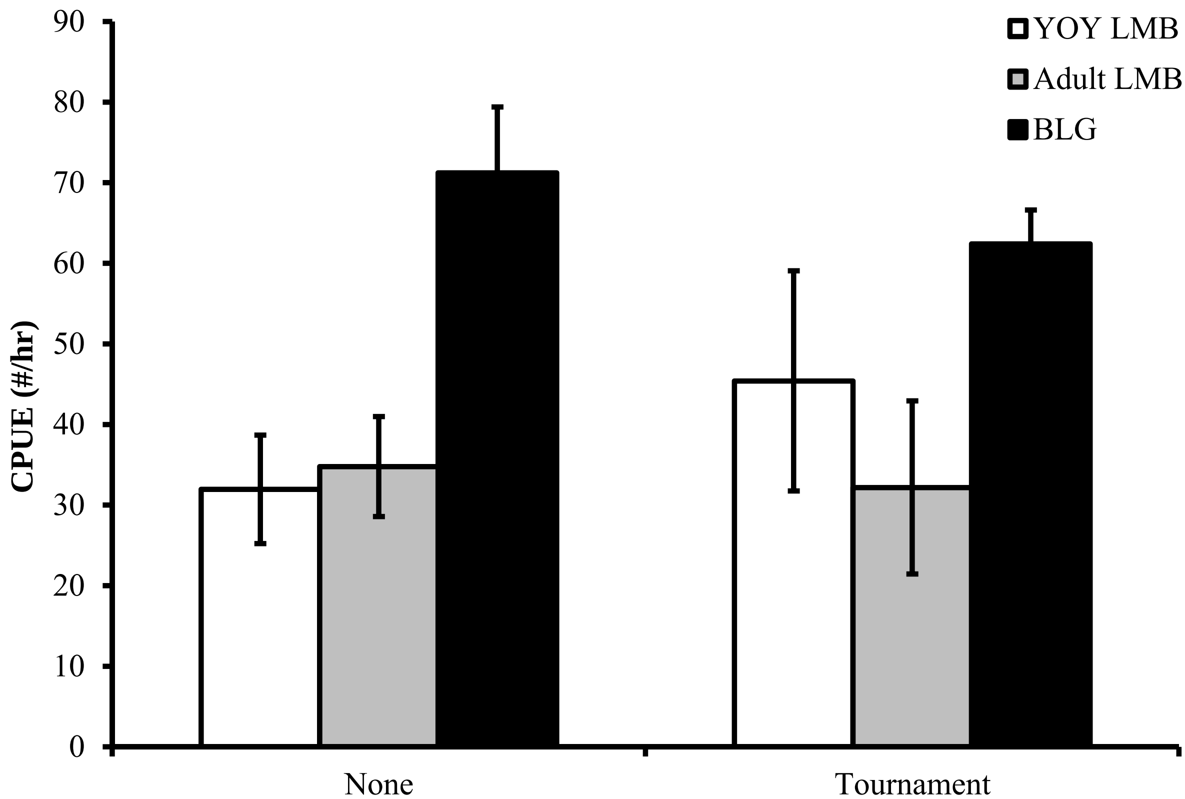

Figure 102.7: Catch per unit effort from spring electrofishing at Ridge Lake in years with tournaments and years without. Catch rates are reported form young-of-year (YOY) largemouth bass, big Largemouth bass (>200 mm), and Bluegill (BLG).

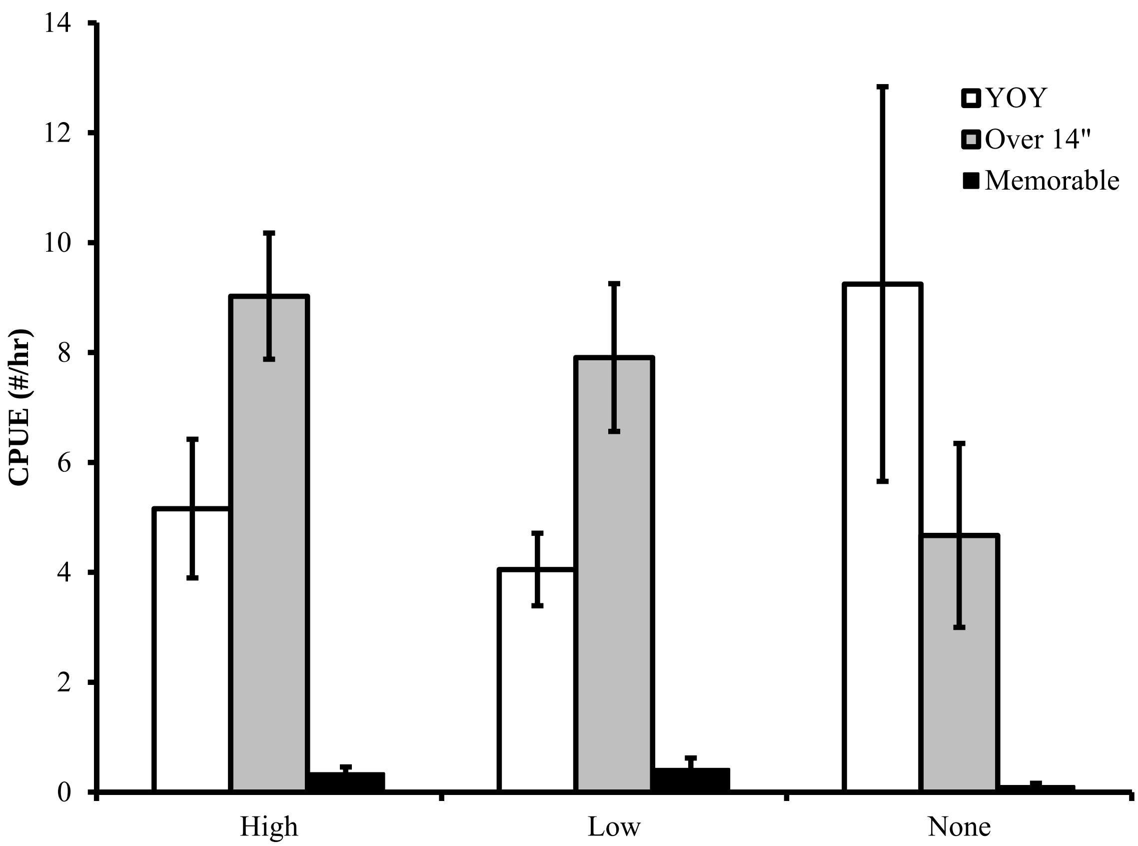

Figure 102.8: Mean catch per unit effort (CPUE) of young-of-year (YOY), Over 14”, and memorable sized (> 509mm) largemouth bass in electrofishing samples in lakes with varying largemouth bass tournament pressure. Tournament pressure was categorized as high (> 3 angler hours per acre), low (< 3 angler hours per acre), or none. Error bars represent standard error.

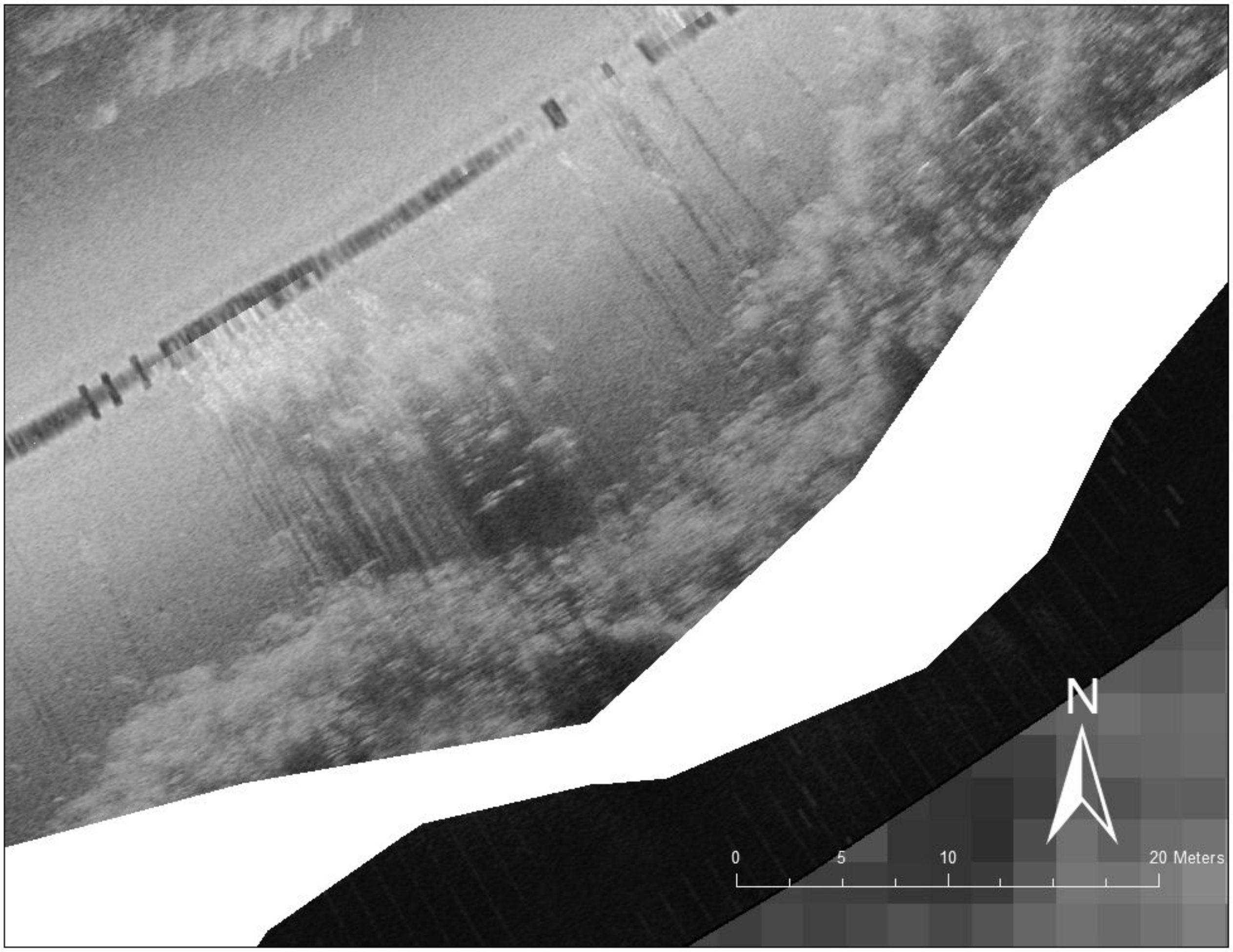

Figure 103.1: Side scan images of Ridge Lake overlayed by vegetation area measured using visual efforts. The white polygon represents visually assessed vegetation, the black is the shoreline, and the cloudy grey area is the offshore vegetation that was measured by the side scan that was not included in the visual estimates. Woody structure can be white objects casting a shadow from the center to the lower right of the image.

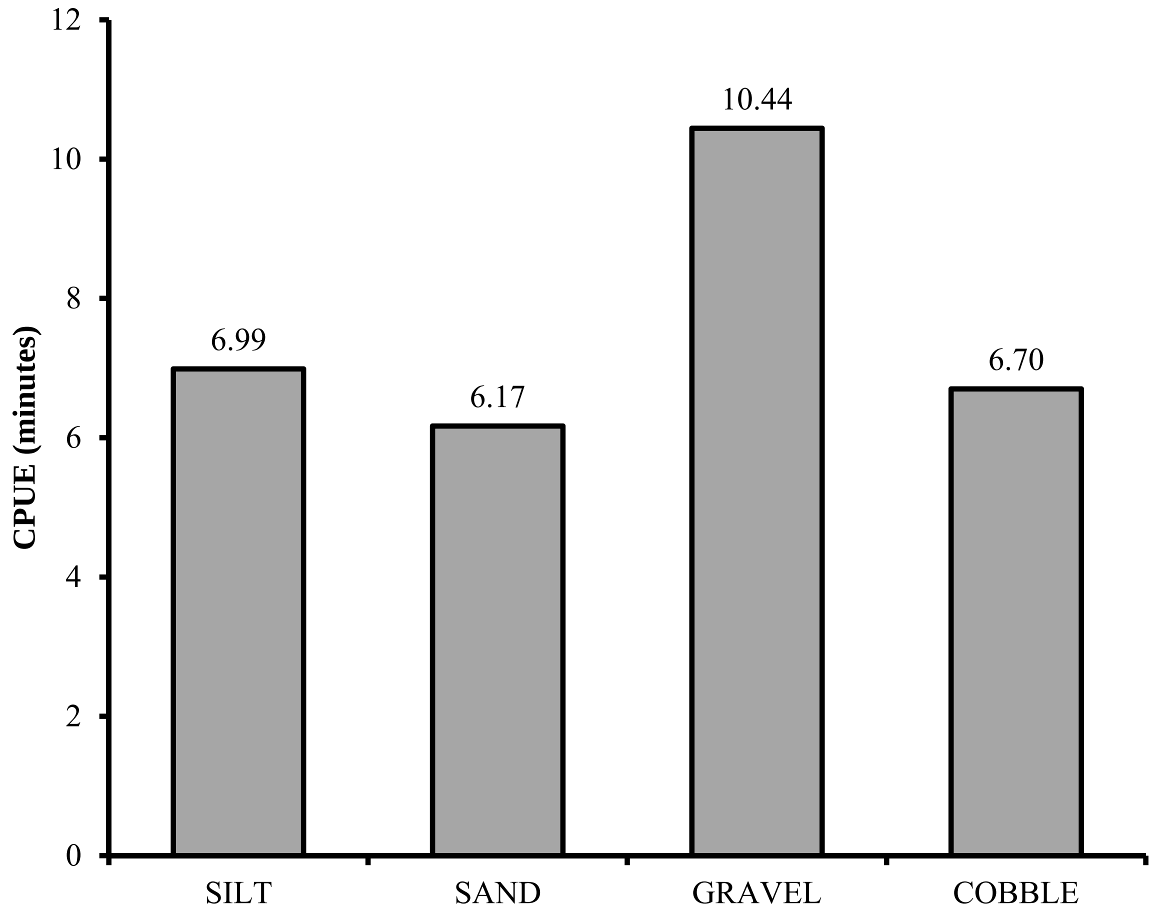

Figure 103.2: Catch per unit effort (CPUE) for fish in the Kaskaskia River in sites dominated by one of four substrates.

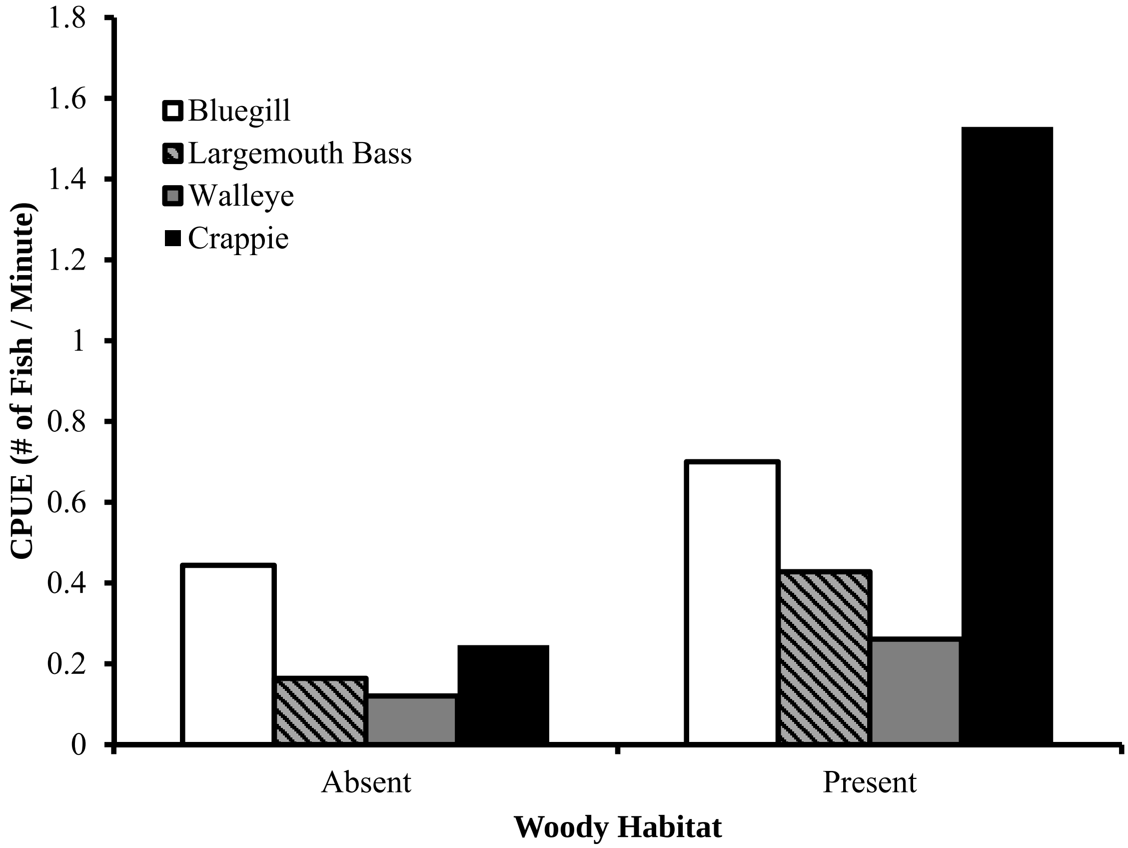

Figure 103.3: Catch per unit effort (CPUE) for fish in the Kaskaskia River in sites where woody habitat was present and sites absent of woody habitat.

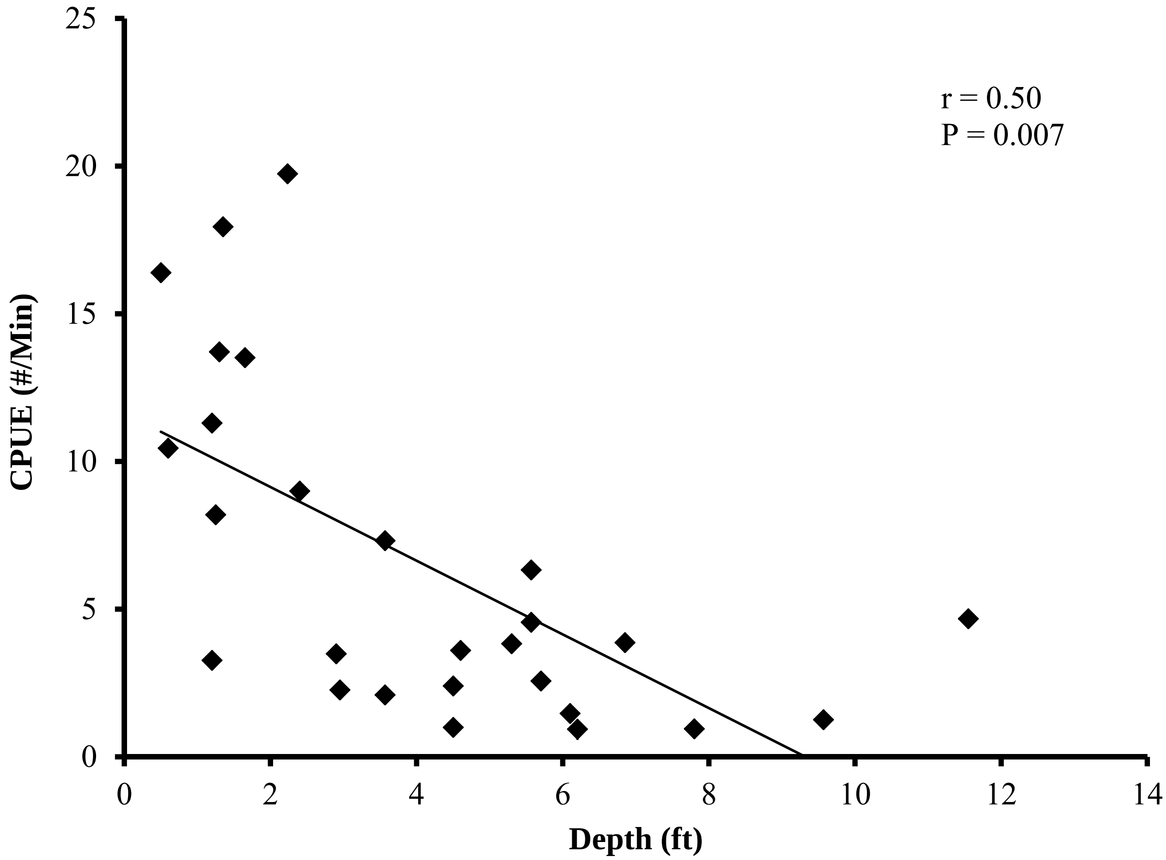

Figure 103.4: Catch per unit effort (CPUE) per minute of electrofishing compared to depth in feet at sites sampled in the Kaskaskia River, 2013 - 2014.

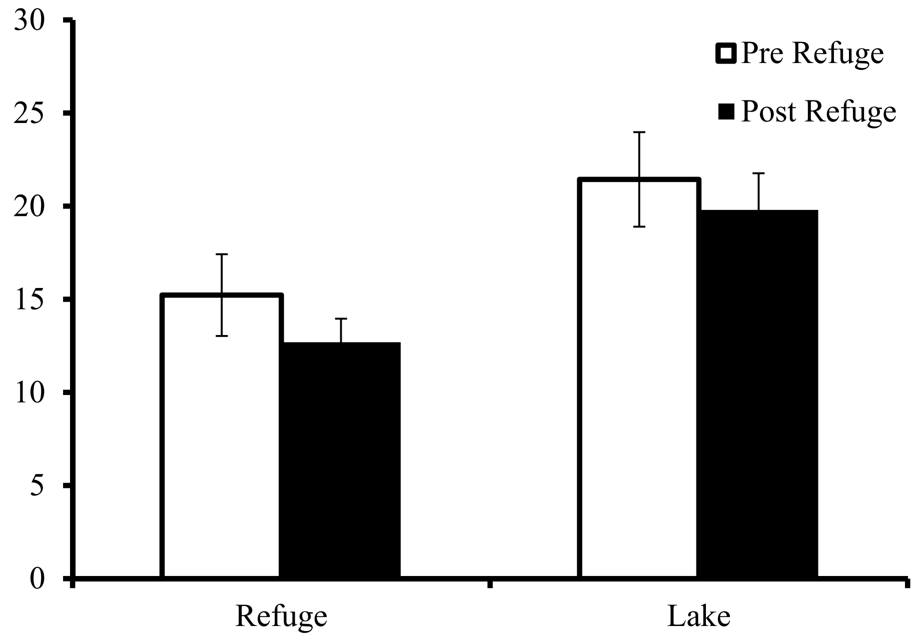

Figure 104.1: Catch per unit effort (CPUE) of largemouth bass in spring and fall electrofishing transects in Otter Lake in refuge sites that were closed to angling compared to lake sites that were not closed to angling. Pre refuge samples were collected in 2007-2010 and post refuge samples were collected in 2011 – 2014. Error bars represent standard error.

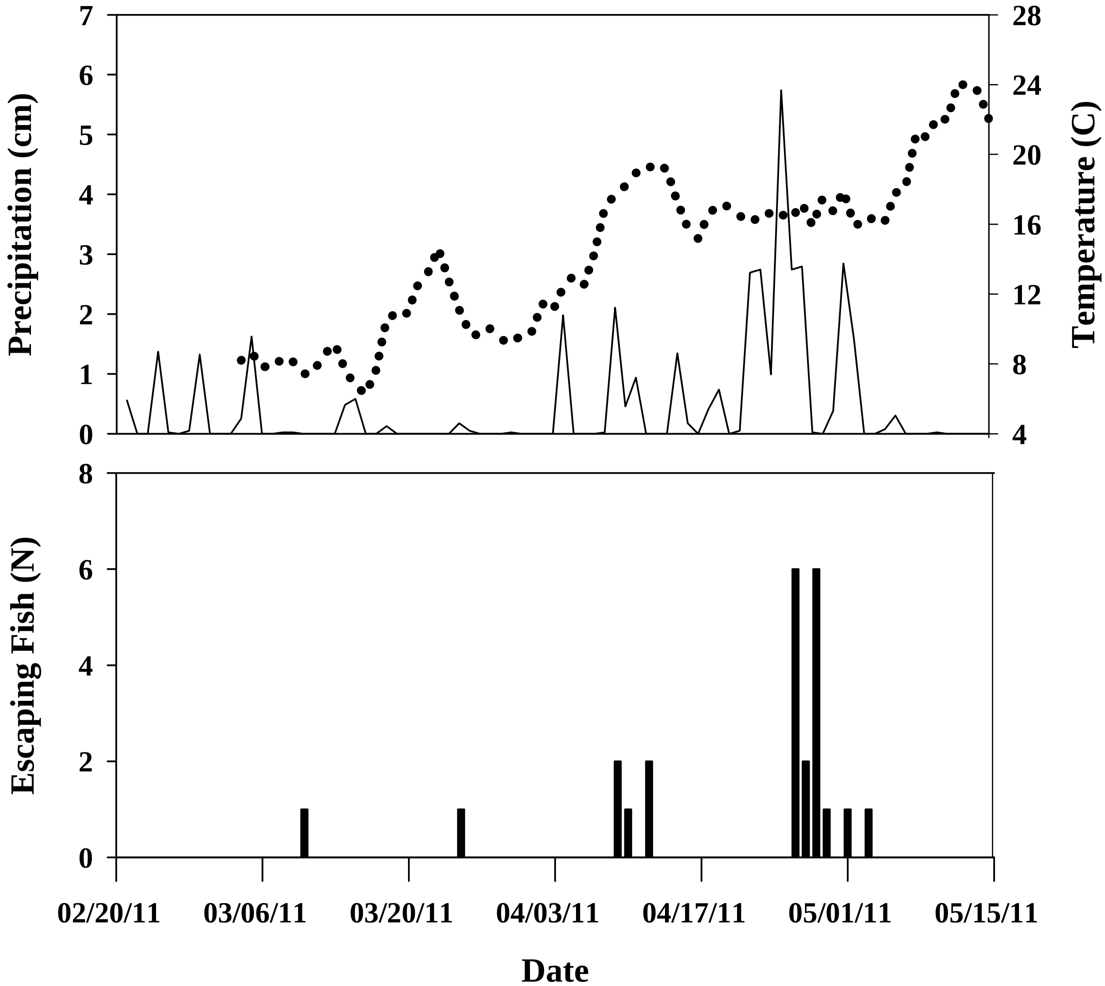

Figure 104.2: Daily precipitation (solid line) and water temperature (dotted line) in the spring and fall at Lake Sam Dale, Illinois (top panel). Daily number of fish escaping over the dam is shown as vertical bars (lower panel). Escapement was determined by tag detections on a PIT tag antennae covering the lower portion of the spillway.

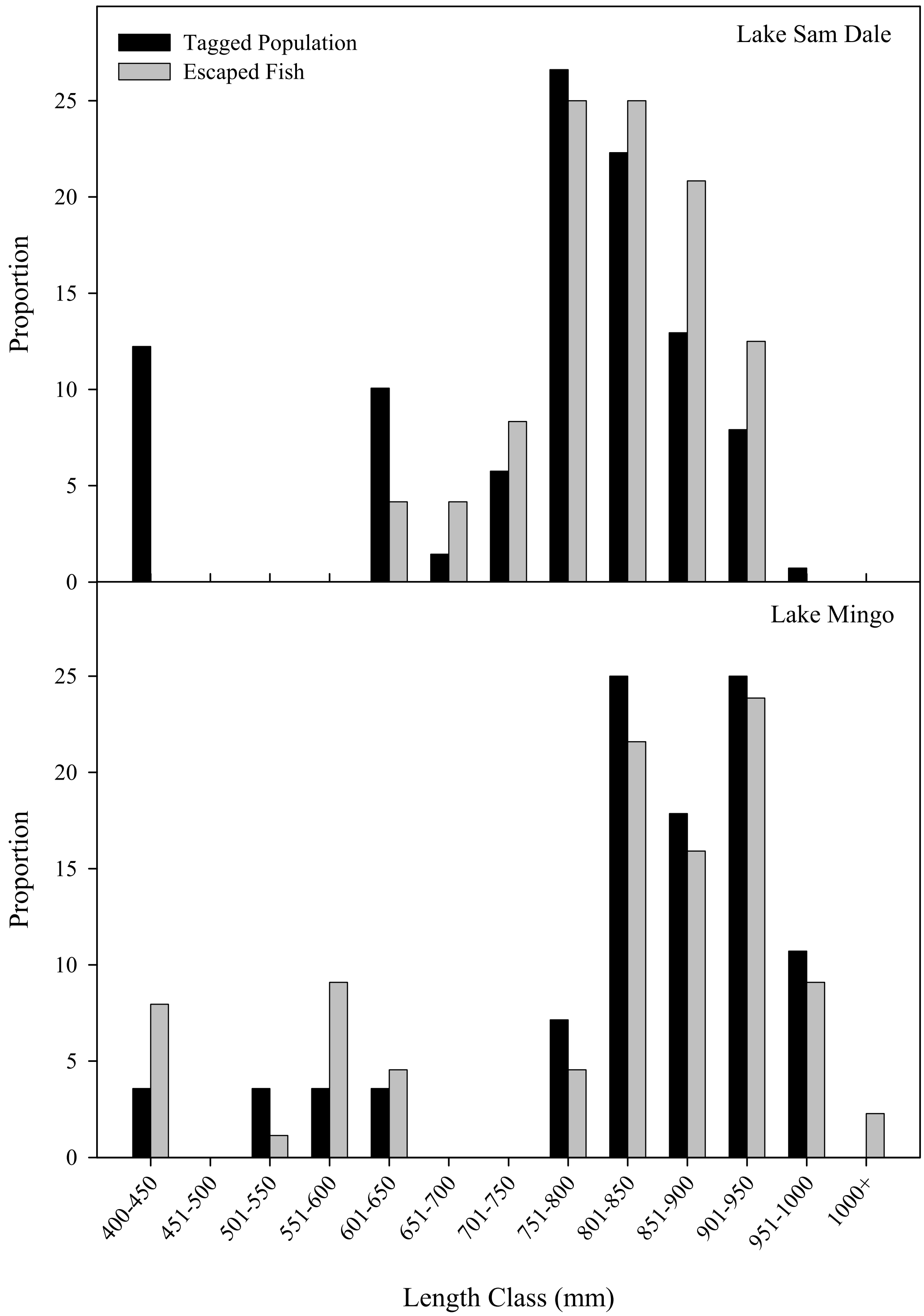

Figure 104.3: Length histogram of the tagged and escaped portion of the muskellunge population in Lake Sam Dale and Lake Mingo through 2012.

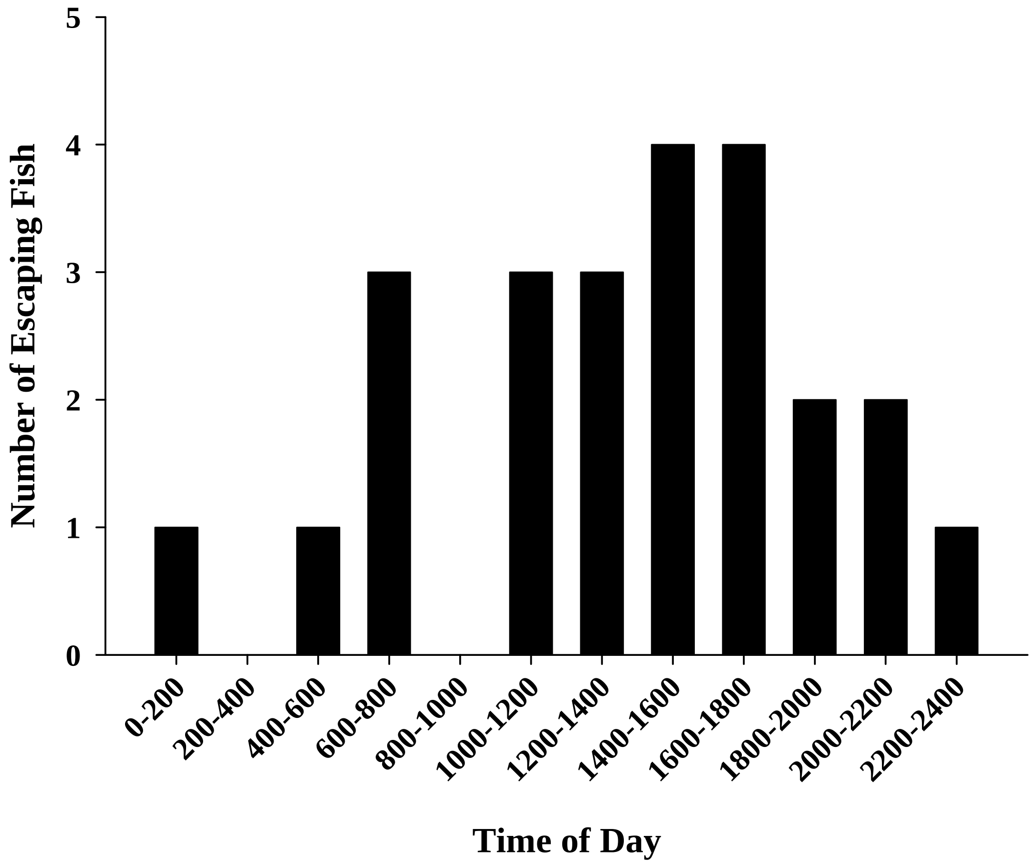

Figure 104.4: Ordinal timing of escapement for muskellunge leaving Lake Sam Dale, Illinois in the spring. Escapement timing was determined by first detection of PIT tags by an antenna covering the spillway below the dam.

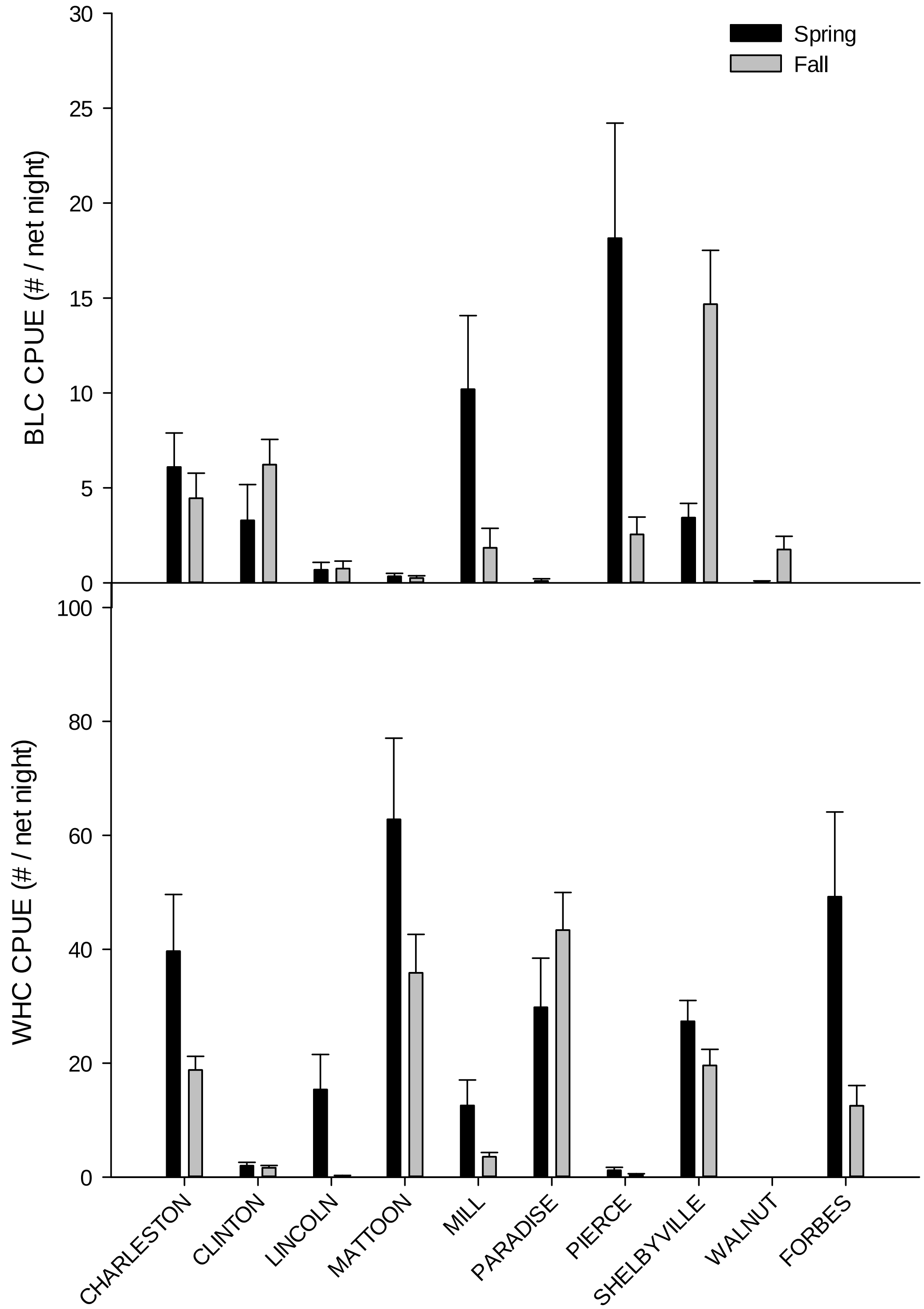

Figure 104.5: Mean CPUE of black crappie (BLC) and white crappie (WHC) during spring and fall in Illinois lakes (N=10). Error bars indicate standard error

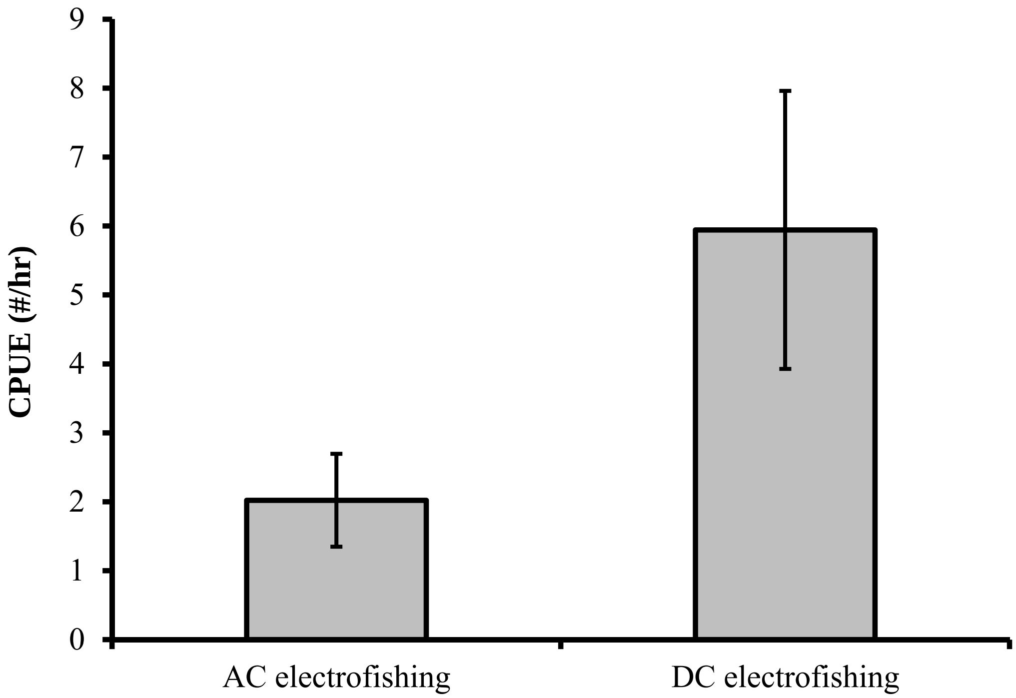

Figure 105.1: Catch per unit of common carp caught in AC and DC electrofishing transects conducted on 15 lakes in the spring of 2014. Error bars represent the standard error.

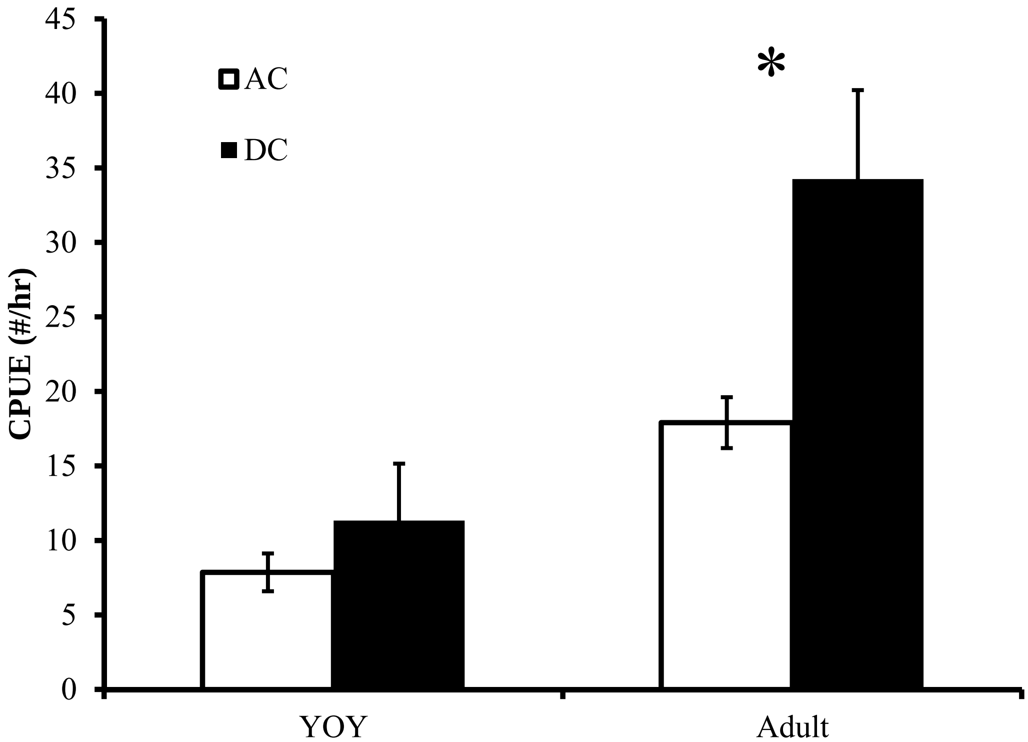

Figure 105.2: Catch per unit of largemouth bass caught in AC and DC electrofishing transects conducted on 15 lakes in the spring of 2014. Largemouth bass were separated in to young-of-year (YOY) and adult (>200mm) size classes. Error bars represent the standard error.